OPERATING AND SERVICE MANUAL

3460B

DIGITAL VOLTMETER

3460B

HEWLETT hp PACKARD

HEWLETT hp PACKARD

CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard. No other warranty is expressed or implied. We are not liable for consequential damages.

Service contracts or customer assistance agreements are available for Hewlett-Packard products that require maintenance and repair on-site.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

OPERATING AND SERVICE MANUAL

-hp- Part No. 03460-90004

MODEL 3460B
DIGITAL VOLTMETER

Serials Prefixed: 709-, 732-, 813-, 925-

P.O. Box 301, Loveland, Colorado, 80537 U.S.A.

Printed: JULY 1969

CAUTION

DO NOT TOUCH ANY COMPONENTS OR CONNECTORS WITHIN THE MODEL 3460B UNLESS CLEAN RUBBER GLOVES ARE WORN. DO NOT REMOVE TOP OR BOTTOM COVERS, AND GUARD COVERS UNLESS ABSOLUTELY NECESSARY. OTHERWISE, LEAKAGE PATHS CAUSED BY FINGERPRINTS AND/OR DIRT ON COMPONENTS, CONNECTIONS OR PC BOARDS WILL REDUCE ACCURACY.

MANUAL CHANGES

MODEL 3460B

DIGITAL VOLTMETER

Manual Part No. 03460-90004

► New or Revised Item

ERRATA

Page 5-13. In CAUTION, change reference to Paragraph 5-28 to read 5-31.

► **Page 5-26, Fig. 5-11.** Change first and second sample to 100 ms.

Page 6-4. Change Part No. of A1Q1 to 1854-0475.
Change Part No. of A1Q4 to 1853-0010. Delete 2N2189.
Change Part No. of A2Q4, Q7 to 1853-0086, Type No. to 2N5087.

Page 6-6. Change all 1901-0026 diodes in A4 to 1901-0158.

Page 6-16. Change A14CR2 to 1901-0025; Diode: Si 100 mA at + 1 V 100 piv 12 picofarads; 93332; D3072.
Change A14CR17 to 1902-0049.

Page 6-21. Change A17Q4 to Part No. 1854-0475. Change A17R7 to 0683-1035; 1/4 Watt.

Page 6-22. Change all 1901-0026 diodes in A18 to 1901-0158.

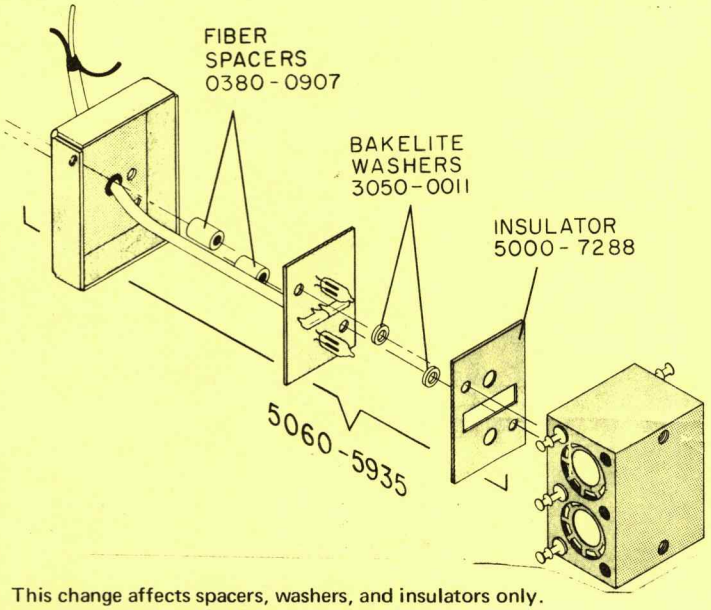
Page 6-23. Add A19; 03460-69506; Replacement Assy: Reference power supply.

Page 6-33. Delete reference to 2140-0044.
Change A39R98 to 0698-4507; R: fxd met flm 76.8 kilohms 1% 1/8 W; 19701; MF5CT-O (See Page 7-31).

Page 6-36. Change Part No. of A43K10 to 0490-0817.

Page 6-39. Change S6 Part No. to 3101-1234.

Page 7-6. Board drawing of A5A1 (to left). Change R19 to read R9.
Change Photochopper Illustration as shown:



This change affects spacers, washers, and insulators only.
Change 0380-0877 to 0380-0907, change Qty to 2.
Change 2170-0879; Washer, Nylon to read 3050-0011; Bakelite Washer.
Add 5000-7288; Qty 1; Insulator.
The above improved parts should be used for all replacements.

Page 7-7. A43, A50 schematic. Add A50 to R26, K6, C1, C2, K11, K12, R29, and R30 designations.
Change polarity of supply connected to A5R40 to + 25 V.

Page 7-15. Change Q13, Q17, and Q21 to PNP.
Change source voltage at R87 (near Q22) to + 10 V.

Page 7-17. Change Q18 to PNP.

Page 7-37. Change emittor voltage of Q4 to - 17 V.
Change Q3 to PNP.

CHANGE 1: FOR SERIAL NO. 949-00946 AND ABOVE

Page 6-0. Change Part No. of MP3 to 03460-00204.

Page 6-4. Q4 is a 1853-0010, TSTR: Si PNP.

Page 6-33, 7-33. Change Part No. of A40 from 03460-66540 to 03462-66540.

Page 6-39. Change Part No. of J29 to 1251-2357.

Page 6-40. Change Part No. of W1 to 8120-1348.

CHANGE 2: FOR SERIAL NO. 949-01046 AND ABOVE.

Page 6-39. Change F1 to 2110-0312, 1 AT for 115 V; to 2110-0202, 500 mAT for 230 V. This change is recommended for all instruments.

CHANGE 3: FOR SERIAL NO. 949-01071 AND ABOVE.

Page 6-39. Change J29 Part No. to 1251-2357.

CHANGE 4: FOR SERIAL NO. 977-01096 AND ABOVE.

Page 6-0. Change MP2 Part No. to 03460-00205.

Page 6-3. Change MP19 Part No. to 0370-0133.

Page 6-39. Change DS1 Part No. to 2140-0008.
Add (to DS1) 5040-0235; lampholder base.
Add (to DS1) 5040-0234; lampholder lens.
Change S1 Part No. to 3100-2707.
Add S8: 3101-0003; power switch.
Change S4 Part No. to 3100-2708.

Page 7-21. Change S1A designation to S8.
Change LOCAL designation to LINE ON.
Delete REMOTE designation.
Delete TRIGGERING designation.

CHANGE 5: FOR SERIAL NO. 977-01121 AND ABOVE.

Page 6-23. Change A19C2 Part No. to 0180-1735; description to C: fxd 0.22 microfarad 30 V.

Page 7-23. Change A19C2 to 0.22 microfarad and connect A19C2 from PIN J of A19A1 to ▽5▽.

CHANGE 6: FOR ALL REPLACEMENT.

Page 6-4. Change A2Q4 to 1850-0062, TSTR: Ge PNP 2N404

Page 6-17. Change Q10 to 1850-0111, TSTR: Ge PNP 2N404A

Page 6-22. Change CR5 to 1902-3182, Diode: Breakdown 12.1 V.
Change R8 to 2100-0439, R: Var 250 Ohm 20%.

Page 6-23. Change A19A1 to 03462-66507.
See part changes under CHANGE 8.

Page 7-23. Change A19A1 as shown under CHANGE 8.

CHANGE 7: FOR ALL SERIAL NUMBERS.

Page 6-0. The part numbers shown are for blue instruments.
The part numbers for brown instruments are listed below.

MP2	03460-00206
MP4	5000-8527
MP5	5000-8529
MP6	03460-04111
MP7	03460-04112
MP9	5060-8737
MP13	03460-84403

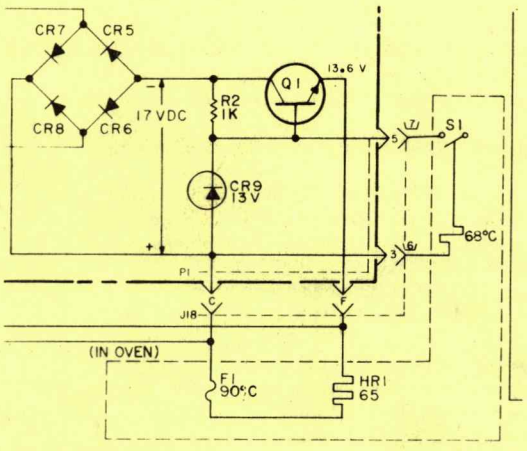
CHANGE 8: FOR SERIAL NO. 1212A01326 AND GREATER.

Page 3-1, Paragraph 3-3. At the top of the second column, under NOTES, change the warm-up time to 45 minutes.

Page 5-1, Paragraph 5-5. In NOTE, change warm-up time to 45 minutes.

Page 6-23. Change A19A1 to 03462-66507.
A1Q1 is 1854-0072, TQ1, TSTR: Si NPN Jedec type 2N3054.
A1CR9 is 1902-3190, Diode: breakdown 13.0 V 5 %.

Page 7-23. On schematic, change part number of "P/O A19A1 oven-controlled power supply" to 03462-66507.
Change circuitry associated with Q1 as shown:



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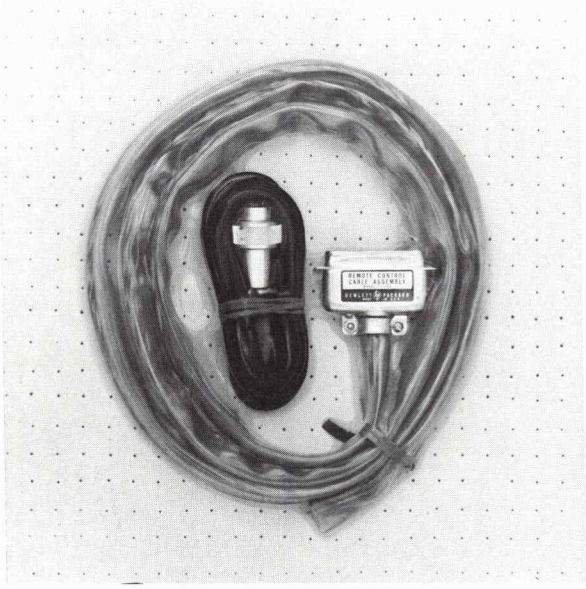
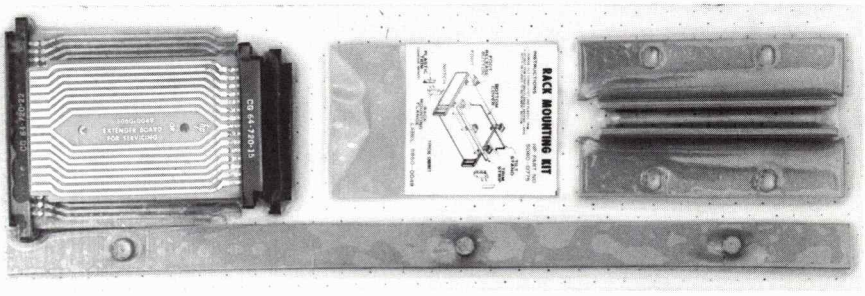
LIST OF ILLUSTRATIONS

3460B



REAR INPUT AND REMOTE CONTROL CABLE ASSEMBLIES

POWER CORD



RACK MOUNTING KIT

Figure 1-1. Model 3460B and Accessories

3460B SPECIFICATIONS

Table 1-1

RANGES

Full Range Display:
±1.00000 V
±10.0000 V
±100.000 V
±1000.00 V

Overranging:
20% on all ranges.

Range Selection:
Manual, automatic or remote.

PERFORMANCE RATING

Accuracy:
90 day calibration cycle:
±(0.004% of reading +0.002% of range).
180 day calibration cycle:
±(0.007% of reading +0.003% of range).
Accuracy applies over a temperature range of 25°C ±5°C.

Stability:
±(0.002% of reading +0.001% of range).
24 hr, constant temperature ±1°C.

Temperature Coefficient:
±(0.0002% of reading +0.0001% of range) per° C.
Derate accuracy specifications by this temperature coefficient for operation in temperature range of 0°C to 20°C and 30°C to 50°C.

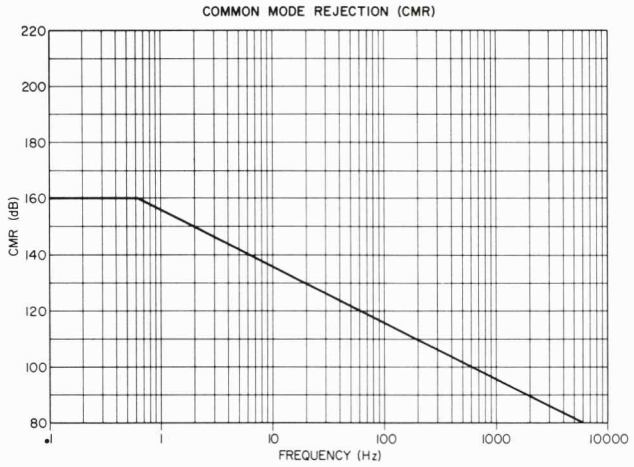
Reading Period:
10,100, 1000 V ranges: < 66 ms.
1 V range: < 150 ms.
Filter adds 725 ms to reading period.
Integration period:
1/10 sec (1/60 sec selectable by external contact closure to ground on 10, 100 and 1000 V ranges).
Response time:
Reads within specified accuracy when triggered coincident with step input voltage.
Autorange time:
33 ms per range change.
Filter adds 363 ms to autorange time.
Remote ranging time: 8 ms.

INPUT CHARACTERISTICS

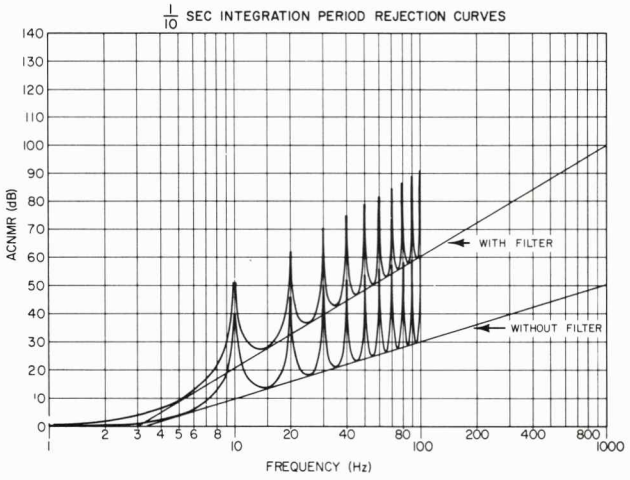
Input Resistance:

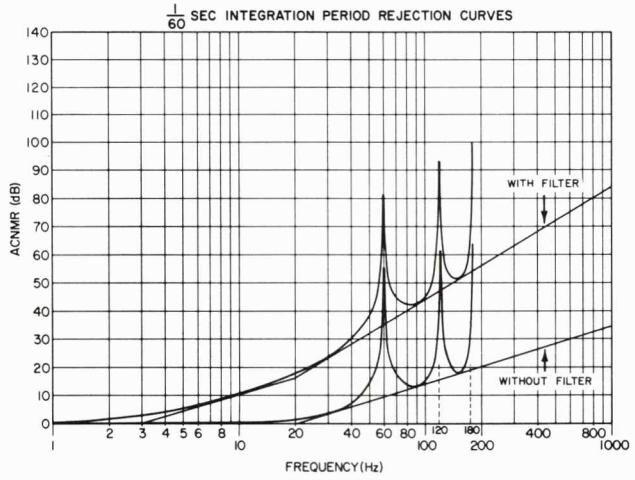
Range	Specification
1V and 10V	$> 10^{10}$ Ω within ±5% of null, otherwise 10MΩ ±0.03%
100V and 1000V	10MΩ ±0.03%

Common-Mode Rejection (CMR):
CMR is the ratio of the peak common-mode voltage to the resultant normal-mode signal with 1 kilohm unbalance in either input lead. Applies to all functions.



AC Normal-Mode Rejection (ACNMR):
ACNMR is the ratio of the peak ac normal-mode signal to the resultant error in reading. Applies to DC and Ohms functions.

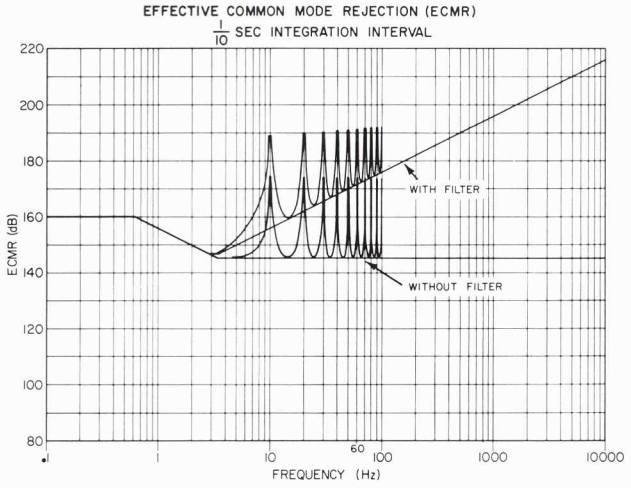


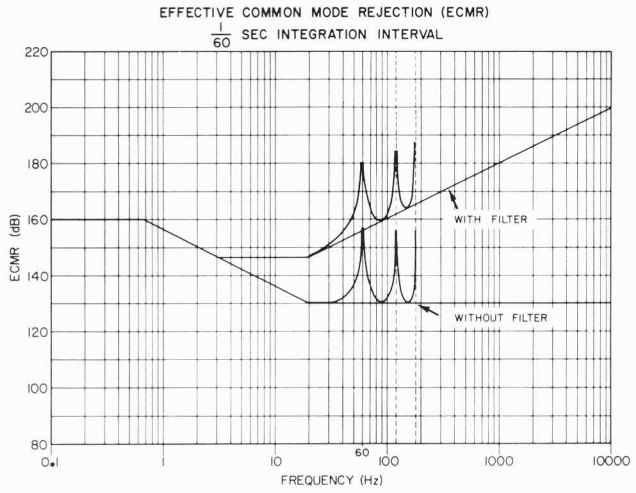


3460B SPECIFICATIONS (CONT'D)

Effective Common-Mode Rejection (ECMR):

ECMR is the ratio of the peak common-mode voltage to the resultant error in reading with 1 kilohm unbalance in either lead. Applies to DC and OHMs functions.





Isolation Parameters:

Floated and guarded input terminals; guard can be operated up to ±500 V peak with respect to chassis ground, low can be operated up to ±50 V peak with respect to guard.

REMOTE CONTROL

Range Selection:

Remote: all ranges can be selected by a contact closure to ground with impedance of $<100\,\Omega$ for a period $>100\,\mu$s.

Automatic: automatic mode of range selection can be programmed by a contact closure to ground with impedance of < 100 ohms.

Filter: can be programmed out by a contact closure to ground with impedance of < 100 ohms.

External Read Command:

Trigger	Open Ckt Voltage	Trigger Level	Duration	Load
Positive going Direct coupled	-10 V	0 V or contact closure to ground	100 μs to 10 ms	1 mA at 0 V 6 mA at +30 V
Negative going Direct coupled	+10 V	-10	100 μs to 10 ms	2 mA at -10V,5 mA at-30 V
AC Coupled		20 V p-p with rise time $\leq 10\,\mu$s	$>100\,\mu$s	6 kΩ in parallel with 25 pF (0.01 μF coupling capacitor used)

Integration Period:

Voltmeter normally integrates for 1/10 s. Contact closure to ground of < 100 ohms selects 1/60 s integration period on 10, 100 and 1000 V ranges.

D/A Converter Reset:

Contact closure to ground of <100 ohms.

Trigger Hold-Off:

Hold-off voltage is +3 to +10 V with a maximum current of 6.3 mA (provided by any external device).

Input Resistance:

10 megohms ±0.03% can be programmed by contact closure to ground of <100 ohms.

RECORDER DATA

Print Command:

dc coupled.

Print Level: -1.0 V with 2 kilohms source resistance.

Print Hold-Off Level: -17 V with 7.5 kilohms source resistance (minimum load resistance is 15 kilohms).

BCD Outputs:

4-line BCD (1-2-4-8) "1" state positive, 9 columns of information.

1 column for function (polarity),
1 column for decimal location,
1 column for overload indication,
6 columns for digits of data.

(HP 3460B Option 001 available for 1-2-2-4 BCD "1" state positive).

BCD Reference Levels:

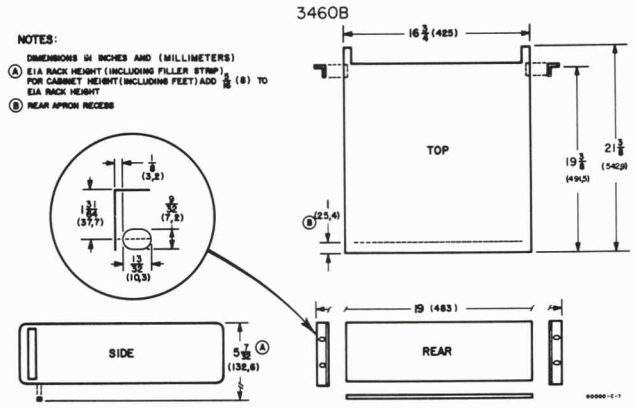
STATE	VOLTAGE	SOURCE RESISTANCE
0	- 24 V	100 K
1	- 1 V	100 K

REF LEVELS:	VOLTAGE	SOURCE RESISTANCE
POSITIVE:	- 4 V	380 ohms
NEGATIVE:	- 21 V	900 ohms

3460B SPECIFICATIONS (CONT'D)

Options	BCD Code "1" State Positive		3461A Compatability	Filter
	1-2-4-8	1-2-2-4		
001		X		
002	X		X	
003		X	X	
004	X			X
005		X		X
006	X		X	X
007		X	X	X

DIMENSIONS



GENERAL

Operating Temperature:
Instrument will operate within specifications from 0°C to 50°C unless otherwise specified.

Storage Temperature:
-40°C to +75°C.

RFI:
Conducted and radiated leakage limits are below those specified in MIL-1-6181D.

Power:
115 V or 230 V ±10%, 50 Hz to 60 Hz, 60 W.
HP 3460B is available on special order for operation with power-line frequencies between 50 Hz and 400 Hz.
HP H50-3460B, optimum noise rejection for 50 Hz line frequency (Same options as 3460B),

Accessories Furnished:
HP 11065A 6-ft rear input cable, guarding preserved;
HP 11085A remote control cable;
HP Part No. 03460-84402 rack mounting kit (includes rack mounting hardware and printed circuit board extenders).

Weight:
Net 38 lb (17,6 kg).
Shipping 52 lb (23,5 kg).

Accessories Available:
HP 3461A AC/Ohms Converter · DC Preamplifier,
HP 562A/AR Digital Recorder, basic instrument with 11-column capacity; column boards, input connector assemblies and cables required for operation are not included.
HP P76-562A/AR Digital Recorder for use with HP 3460B accepting 1-2-4-8 BCD code. Includes special double-wheel characters, 9 BCD columns, 9-column input connector, printer option 30, and one input cable, printer option 32.
HP 5050B Digital Recorder, basic instrument with 18-column capacity and 3 code discs; column boards and cables required for operation are not included,
HP H024-5050B Digital Recorder, includes special print wheel in function column, 5 BCD column boards and option 32 inter-connecting printer cable,

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This section contains general information about the Model 3460B Digital Voltmeter. Included are discussions of the description, Options, and instrument/manual identification. Instrument specifications are given in Table 1-1.

1-3. DESCRIPTION.

1-4. The 3460B Digital Voltmeter is a compact, highly accurate, fast reading, multi-purpose digital voltmeter with the measuring circuits fully isolated from the chassis (guarded). The instrument provides a 6-place in-line display (and polarity indicator) of measured voltage from 0.00001 to 1199.99 volts dc with 10 microvolt resolution on the 1 volt range. Accuracy of reading is within ±0.004% of reading ±2 digits of the voltage being measured in ambient temperatures between +20°C and +30°C. Various reading rates up to 15 per sec can be programmed remotely, or a reading rate of 1 per 5 sec up to 3 per sec can be selected by the front panel RATE control for local operation. Input guarding attenuates common mode signals by more than 160 dB at dc and 120 dB at 60 Hz with 1000 ohms or less between LOW and GUARD. Superimposed noise rejection by integration (ratio of superimposed noise to its effect on the digital display) is shown in Table 1-1. Four input-voltage ranges 1.00000, 10.0000, 100.000 and 1000.00, can be selected by pushbuttons, remote control, or automatically for each applied voltage. Overrange capability enables voltages to be measured within specified accuracy up to 20% above the selected range. A lighted decimal light is automatically positioned so the display always reads directly in volts. Input resistance is a constant 10 megohms on the 1000 V and 100 V ranges, increasing to a constant 10^{10} ohms on the 10 V and 1 V ranges if a D-to-A Converter Reset is not programmed and the input voltage does not change by 5% between reading periods (1% if a 1/60 Sec Sample Select is programmed). However, with a changing input voltage or a D-to-A Converter Reset, only the 2nd sample period has the higher input resistance. Digital display tubes provide the display in a darkened area covered by a polarized filter, which prevents reflections of external lighting. A constant input voltage provides a non-blink display in all digits.

1-5. TYPE AND PURPOSE.

1-6. The 3460B is an integrating potentiometric voltmeter that measured the average value of the input voltage during a fixed sample period. The 3460B is designed especially for dependable, high-accuracy measurements that can be remotely programmed at a high reading rate.

1-7. STABILITY.

1-8. A ±10% change in line voltage on either 115 or 230 volt ac line has no effect on voltmeter operation. Vibration and normal shock incurred in transporting has no effect on the accuracy or stability of the voltmeter. Long term stability is such that a calibrated voltmeter will remain within specified accuracy for a period of three months.

1-9. REMOTE CONTROL.

1-10. A REMOTE CONTROL connector (J27) on the rear panel of the 3460B is provided for remote programming of range and triggering rate. Individual range selection is made by a simple switch closure to ground, either momentary or permanent. Automatic ranging is selected by a continuous switch closure to ground. The reading rate can be remotely programmed for various speeds depending upon remote triggering rate and integration interval (1/60 or 1/10 sec) desired. The REMOTE CONTROL connector is also used for ac and ohms measurements with the Optional 002, 003, 006 and 007 3460B and the -hp- 3461A, AC/Ohms Converter-DC Preamplifier.

1-11. DIGITAL RECORDER OUTPUT.

1-12. Each digit, decimal point location, polarity and overload indication is presented in four-line binary coded decimal (BCD) at RECORDER connection (J28) for recording of measured data on a printer such as the Hewlett-Packard Model 562A Digital Recorder.

1-13. The BCD output on a standard instrument is 1-2-4-8 "1" state positive. Refer to Table 1-1 for BCD reference levels.

1-14. CONSTRUCTION.

1-15. The 3460B is constructed for both bench-top use and rack-mounted operation. It is equipped with recessed carrying handles on each side, guardrails on the front panel and plastic feet and a tilt stand on the bottom. A rack mounting kit is furnished with instrument.

1-16. OPTIONS AVAILABLE.

1-17. The 3460B is offered as a standard instrument or with any one of seven options. Basic differences between the eight configurations are described below:

Standard Instrument: BCD output is 1-2-4-8 "1" state positive at RECORDER connection (J28) on instrument rear panel.

Option 001: BDC output is 1-2-2-4 "1" state positive at RECORDER connection (J28) on instrument rear panel.

Option 002: BCD output is 1-2-4-8 "1" state positive at RECORDER connection (J28) on instrument rear panel. Option 002 is modified to be compatible with the -hp- 3461A AC/OHMS Converter-DC Preamplifier.

Option 003: BCD output is 1-2-2-4 "1" state positive at RECORDER connection (J28) on instrument rear panel. Option 003 is modified to be compatible with the -hp- 3461A AC/OHMS Converter-DC Preamplifier.

Option 004: Standard instrument with filtering circuits.

Option 005: Option 001 with filtering circuits.

Option 006: Option 002 with filtering circuits.

Option 007: Option 003 with filtering circuits.

1-18. INTERCHANGE OF OPTIONS.

1-19. A 3460B can be modified to accept the -hp- AC/OHMS Converter (-hp- 3461A). In this way a standard instrument can be made into an Option 002; an Option 001 into an 003; an 004 into an 006; and an 005 into an 007.

1-20. It is impractical to install a filter on an unfiltered instrument or to change BCD codes.

1-21. INSTRUMENT/MANUAL IDENTIFICATION.

1-22. Hewlett-Packard uses a two-section eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual or Manual Backdating Changes in Appendix C, will define differences between your instrument and the Model 3460B described in this manual.

1-23. ACCESSORIES/EQUIPMENT SUPPLIED.

1-24. The accessories and equipment supplied with each Model 3460B Digital Voltmeter are listed in Table 1-2.

Table 1-2. Accessories/Equipment Supplied

MODEL OR PART NO.	QUANTITY	DESCRIPTION
-hp- Model 11065A	1	Rear Input Cable Assembly
-hp- Model 11085A	1	Remote Control Cable Assembly
-hp- Part No. 03460-84402	1	Rack Mounting Kit Includes 3 printed-circuit boards
-hp- Part No. 8120-0078	1	Power Cord
-hp- Part No. 03460-90004	1	Operating and Service Manual

1-25. ACCESSORIES AVAILABLE.

1-26. The accessories available to increase the usefulness of the 3460B are listed in Table 1-3. For further information, contact your local -hp- Sales and Service Office. (See Appendix B for office locations.)

Table 1-3. Accessories Available

MODEL OR PART NO.	DESCRIPTION
-hp- Part No. 5060-0049	15-pin plug-in, printed-circuit board extender
-hp- Part No. 5060-0630	22-pin plug-in, printed-circuit board extender
-hp- Model No. 562A	Digital Recorder, for use with 3460B to record measured data (1-2-4-8 or 1-2-2-4 BCD)
-hp- Model No. 5050B	Digital Recorder, for use with 3460B to record measured data (1-2-4-8 or 1-2-2-4 BCD)
-hp- Model No. 3461A	AC/Ohms Converter-DC Pre-amplifier
-hp- Model No. 3461A 002	AC Converter
-hp- Model No. 3461A 003	Ohms Converter-DC Pre-amplifier

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions necessary for the installation and shipping of Model 3460B Digital Voltmeter. Included are initial inspection procedures, power and grounding requirements, installation information and instructions for repackaging for shipment.

2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be physically free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also check for supplied accessories listed in Table 1-2, and test the electrical performance of the instrument using the procedure outlined in Paragraph 5-5, Performance Checks. If there is damage or electrical deficiency, file a claim with the carrier, and refer to the warranty on the inside front cover of this manual.

2-5. POWER REQUIREMENTS.

2-6. The Model 3460B requires either 115 or 230 volts ac ±10%, 50 to 60 cycles per second and dissipates approximately 60 watts of power. With the instrument disconnected from the ac power source, slide the line voltage switch on the rear panel until the line voltage to be used appears and check fuse for proper value (1 amp slow-blow for 115 volt operation, 1/2 amp slow-blow for 230 volt operation).

CAUTION

DO NOT APPLY OPERATING POWER TO 3460B DIGITAL VOLTMETER UNLESS THE LINE VOLTAGE SWITCH ON THE REAR PANEL IS IN THE PROPER POSITION. OTHERWISE, DAMAGE TO POWER TRANSFORMER WILL RESULT.

2-7. GROUNDING REQUIREMENTS.

2-8. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the cabinet of the instrument. The offset pin on the power cable three-prong connector is the ground wire.

2-9. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the pigtail on the adapter to ground.

2-10. INSTALLATION.

2-11. The Model 3460B is fully transistorized with forced air cooling provided by the blower at the rear of instrument; therefore no external cooling is required. However, the instrument should not be operated where the ambient temperature exceeds +50°C (122°F) or stored in temperatures above +75°C (167°F) or below -40°C (-40°F).

CAUTION

DO NOT OPERATE THE VOLTMETER IF THE BLOWER IS NOT OPERATING PROPERLY, AND CLEAN THE AIR FILTER AS OUTLINED IN SECTION V. OTHERWISE, EXCESSIVE INTERNAL HEAT MAY DAMAGE COMPONENTS WITHIN THE VOLTMETER.

2-12. BENCH USE.

2-13. The Model 3460B is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument.

2-14. RACK MOUNTING.

2-15. The 3460B can be rack mounted by adding mounting brackets to each end of the front panel and by providing additional support at the rear of the voltmeter. The front mounting brackets and mounting hardware (-hp- Part No. 03460-84402) along with instructions for rack mounting are furnished with the instrument.

2-16. The 3460B must not be rack mounted without rear support. The support can be either a drawer or bracket at or near the rear. When rack mounting, be sure the air intake at the rear and the air exhaust along the sides are not obstructed, and that the air intake does not draw in air at a temperature in excess of +50°C (122°F) inside the rack cabinet.

2-17. REPACKAGING FOR SHIPMENT.

2-18. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-19 if the original container is to be used; 2-20 if it is not. If you have any questions, contact your local -hp- Sales and Service Office. (See Appendix B for office locations.)

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair to be accomplished; include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number, serial number, and serial number prefix.

2-19. If original container is to be used, proceed as follows:

a. Place instrument in original container with appropriate packing material if available. A container and packing material can be purchased from your nearest -hp- Sales and Service Office.

b. Ensure that container is well sealed with strong tape or metal bands.

2-20. If original container is not to be used, proceed as follows:

a. Wrap instrument in heavy paper or plastic before placing in an inner container.

b. Place packing material around all sides of instrument and protect panel face with cardboard strips.

c. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.

d. Mark shipping container with "DELICATE INSTRUMENT," "FRAGILE" etc.

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. This section contains instructions and information necessary for operation of the Model 3460B Digital Voltmeter. Included are operating precautions; function of front and rear panel controls, indicators, and connectors; preoperational checks; operating instructions for LOCAL and REMOTE modes of operation; and operating instructions for Option 002, 003, 006 and 007 instrument.

3-3. OPERATING PRECAUTIONS.

CAUTION

a. BEFORE APPLYING OPERATING POWER TO THE VOLTMETER, VERIFY THAT THE LINE VOLTAGE SWITCH ON THE REAR PANEL INDICATES THE LINE VOLTAGE TO BE USED, AND BE SURE THE AIR INTAKE ON THE REAR IS NOT OBSTRUCTED.

b. VERIFY THAT THE V/F CHECK SWITCH ON THE REAR PANEL IS IN CENTER POSITION.

c. DO NOT APPLY MORE THAN 500 VOLTS DC BETWEEN THE GUARD BINDING POST AND POWER-LINE GROUND.

d. DO NOT APPLY MORE THAN 50 VOLTS DC BETWEEN THE GUARD AND LOW INPUT BINDING POST. (SEE PARAGRAPH 3-30.)

e. DO NOT APPLY MORE THAN 1500 VOLTS BETWEEN THE LOW AND HIGH INPUT BINDING POSTS.

f. ON OPTIONS THAT ARE FILTERED, DO NOT MEASURE VOLTAGE FROM A SOURCE RESISTANCE OF GREATER THAN 5 KILOHMS WHEN THE FILTER IS PROGRAMMED IN. THE FILTER TIME CONSTANT WILL BE LENGTHENED BY THE SOURCE RESISTANCE AND THE FILTER WILL NOT HAVE ENOUGH TIME TO RESPOND TO THE DC INPUT.

NOTES

1. After turning on the voltmeter, allow a 15-minute warmup and stabilization period for internal parts to reach normal operating temperature; specified accuracy will then be obtained. However, depending upon the ambient operating temperature and/or period of operation, a Preoperational Check and Calibration as outlined in Paragraph 3-4 should be performed to verify the internal zero setting and Voltage-to-Frequency Converter linearity within the instrument.

2. The instrument will display a non-zero changing readout if the input is open on the 1 V and 10 V ranges due to the High Z Relay A43K10 being open.

3-4. PREOPERATIONAL CHECK AND CALIBRATION.

3-5. After a 15-minute warm-up period, the following checks should be performed to verify the internal zero setting and Voltage-to-Frequency Converter linearity of the instrument.

3-6. ZERO CHECK AND ADJUSTMENT.

a. Set 3460B controls as follows:

LOCAL-REMOTE TRIGGERING ... LOCAL
(Note warmup time)
TRIGGERING RATE .....full CW
REAR-FRONT ..... FRONT
RANGE ..... 1 volt
LOW-TO-GUARD shorting bar .... Connected

b. Short the HIGH and LOW INPUT with a shielded cable.

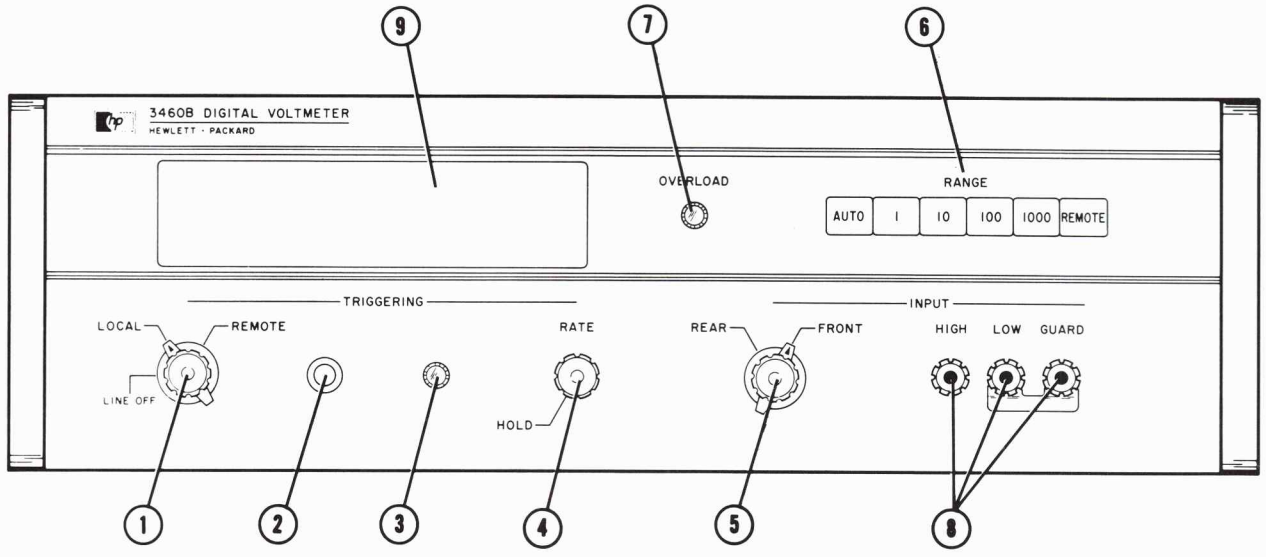
c. Observe .00000 (±1 count) on front panel digital display.

NOTE

If the 3460B does not indicate .00000 (±1 count), perform the following steps:

1. Remove the top cover.

2. Adjust ZERO through the top guard cover for a .00000 (±1 count) digital display.



(1) **LOCAL-REMOTE TRIGGERING** selector applies operating power to instrument, and selects LOCAL or REMOTE mode of operation. (See Paragraph 3-10.)

(2) **TRIGGERING** pushbutton initiates a reading when manually depressed in the LOCAL mode of operation. (See Paragraph 3-41.)

(3) **TRIGGERING** indicator indicates reading period in process when illuminated.

(4) **TRIGGERING RATE** control adjusts the reading repetition rate in LOCAL mode of operation. (See Paragraph 3-41.)

(5) **REAR-FRONT INPUT** switch selects front or rear input connections. (See Paragraph 3-24.)

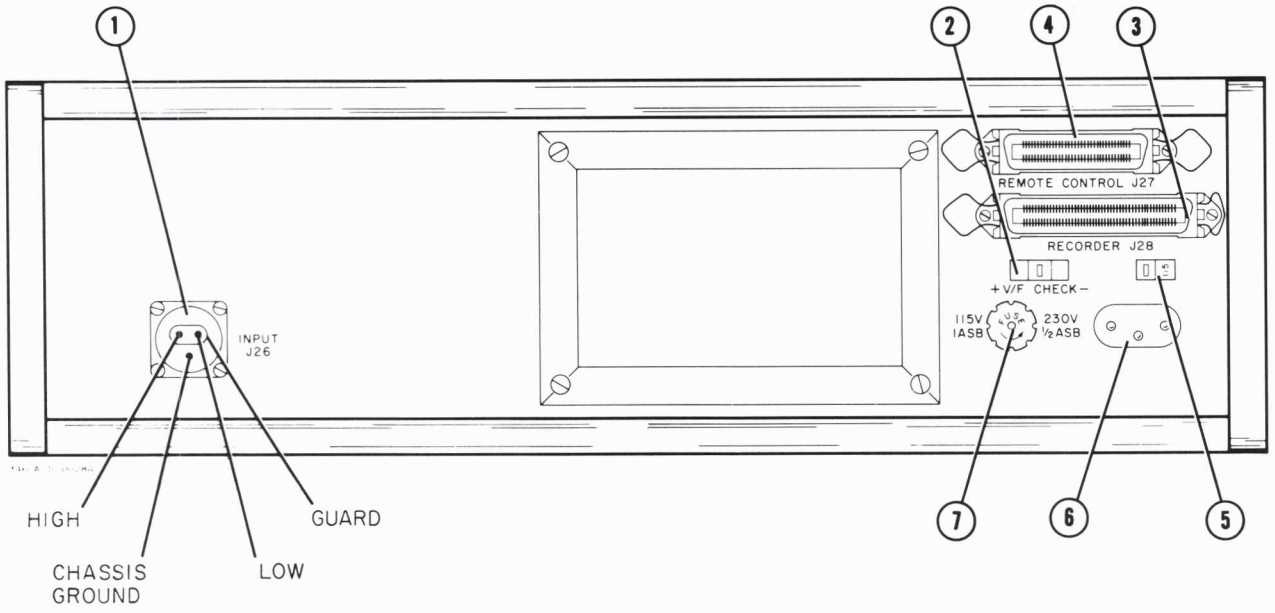
(6) **RANGE** pushbuttons select manual, automatic, or remote control of input voltage range. (See Paragraph 3-33.)

(7) **OVERLOAD** indicator indicates an overload condition (20% above full scale voltage). (See Paragraph 3-39.)

(8) **INPUT** binding posts provide input connections for voltage to be measured when REAR-FRONT INPUT switch is set to the FRONT position. (See Paragraph 3-24.)

(9) **DIGITAL DISPLAY** displays polarity and value of input voltage being measured. Displays function (KΩ or AC) and input value with Options 002, 003, 006 and 007 instruments.

Figure 3-1. Front Panel Controls, Indicators, and Connectors



(1) Rear Panel **INPUT** connector (J26) provides rear panel input connection for voltage to be measured when the **REAR-FRONT INPUT** switch is set to the **REAR** position. (See Paragraph 3-24.)

(2) **V/F CHECK** switch checks Voltage-to-Frequency Converter calibration. (See Paragraph 3-4.)

(3) **RECORDER** connector (J28) provides connections for recording the voltmeter display on a digital recorder. (See Paragraph 3-55.)

(4) **REMOTE CONTROL** connector (J27) provides connections for remote control of voltmeter. (See Figure 3-3.)

(5) Line Voltage slide switch permits selection of 115 or 230 Vac source for the operating power of the instrument. Voltage selected appears on switch. (See Paragraph 2-5.)

(6) Power input connector (J29) connects ac operating power to instrument through power cord furnished with the instrument.

(7) **FUSE** (one amp slow-blow) protects internal circuits of instrument (1/2 amp slow-blow for 230 Vac operation.)

Figure 3-2. Rear Panel Controls, Indicators, and Connectors

3-7. V-TO-F CONVERTER CHECK AND CALIBRATION

a. Set 3460B controls as identified in Paragraph 3-6, steps a and b.

b. Position V/F CHECK switch on the rear panel to + position, and observe a digital display of +1.00000 (±1 count in fourth digit).

NOTE

The last two digits will always indicate zeros during a V-to-F Converter Check.

c. Position V/F CHECK switch on the rear panel to - position and observe a digital display of -1.00000 (±1 count in fourth digit).

d. Return V/F CHECK switch to center position.

NOTE

If the 3460B does not indicate the proper digital display, perform the following steps:

1. Remove the top cover.

2. Position V/F CHECK switch to - position.

3. Adjust V/F CAL (-) through the top guard cover for a -1.00000 (±1 count in fourth digit) digital display.

4. Position V/F CHECK switch to + position.

5. Adjust V/F CAL (+) through the top guard cover for a +1.00000 (±1 count in fourth digit) digital display.

6. Return V/F CHECK switch to center position, and replace the top cover.

3-8. FRONT AND REAR PANEL CONTROLS, INDICATORS, AND CONNECTORS.

3-9. The front and rear panel controls, indicators, and connectors are illustrated and identified in Figures 3-1 and 3-2.

3-10. MODES OF OPERATION.

3-11. The 3460B Digital Voltmeter has two modes of operation, LOCAL and REMOTE:

a. In the LOCAL mode of operation, the triggering of each reading period is internally initiated, with the triggering rate controlled by the RATE control on the front panel.

b. In the REMOTE mode of operation, each reading period is initiated by an external source (one of four triggers) with the range and triggering rate controlled by external switch closures to ground. The range may be remotely controlled by external switch closures to ground only when the REMOTE RANGE pushbutton on the front panel is depressed.

3-12. OPERATING INSTRUCTIONS.

3-13. The following paragraphs contain instructions for operating the Model 3460B in the LOCAL mode of operation and REMOTE mode of operation.

3-14. LOCAL MODE OF OPERATION.

a. Observe the necessary operating precautions listed in Paragraph 3-3.

b. Position LOCAL-REMOTE TRIGGERING selector to LOCAL.

c. Set REAR-FRONT INPUT switch to REAR for rear panel input connections or FRONT for front panel input connections.

NOTE

When using the rear input connection, connect the high, low and guard test leads from the Rear Input Cable (-hp- Model 11065A) in the same manner described in steps e, f, and g.

d. Depress the desired RANGE pushbutton according to voltage level to be measured (see Paragraph 3-33); depressing AUTO RANGE pushbutton selects automatic ranging.

e. Connect HIGH INPUT binding post to the high side of voltage to be measured.

f. Disconnect the GUARD-to-LOW shorting strap and connect LOW INPUT binding post to the low side of voltage to be measured.

NOTE

When guarding (GUARD binding post) is not used, connect the GUARD-to-LOW shorting strap and eliminate step g.

g. Connect GUARD INPUT binding post to shield of circuit containing voltage to be measured, or to LOW INPUT at point of measurement. (See Paragraph 3-24.)

CAUTION

DO NOT CONNECT GUARD TO ANY POINT WHERE THE POTENTIAL DIFFERENCE OF THE LOW AND GUARD INPUTS EXCEEDS 50 VOLTS. OTHERWISE, DAMAGE TO 3460B MAY RESULT.

h. Observe that the OVERLOAD indicator is not flashing after short stabilization period.

NOTE

If OVERLOAD indicator flashes, select higher range.

i. Adjust TRIGGERING RATE control for desired reading rate (see Paragraph 3-41) and observe that the TRIGGERING indicator flashing increases or decreases according to the reading rate selected.

j. Observe digital display for polarity and value of voltage being measured.

3-15. REMOTE MODE OF OPERATION.

3-16. The 3460B may be remotely programmed for use in automatic data acquisition systems or other applications. The required external connections to the REMOTE CONTROL connector (J27) on the rear panel for remote programming are given in Figure 3-3. The Remote Control Cable (-hp- Model 11085A) is used for remote programming. Table 3-1 identifies the Remote Control Cable connections.

3-17. Front Panel Settings.

a. Observe the necessary operating precautions listed in Paragraph 3-3.

b. Position LOCAL-REMOTE TRIGGERING selector to REMOTE.

c. Set REAR-FRONT INPUT switch to REAR for rear panel input connections or FRONT for front panel input connections.

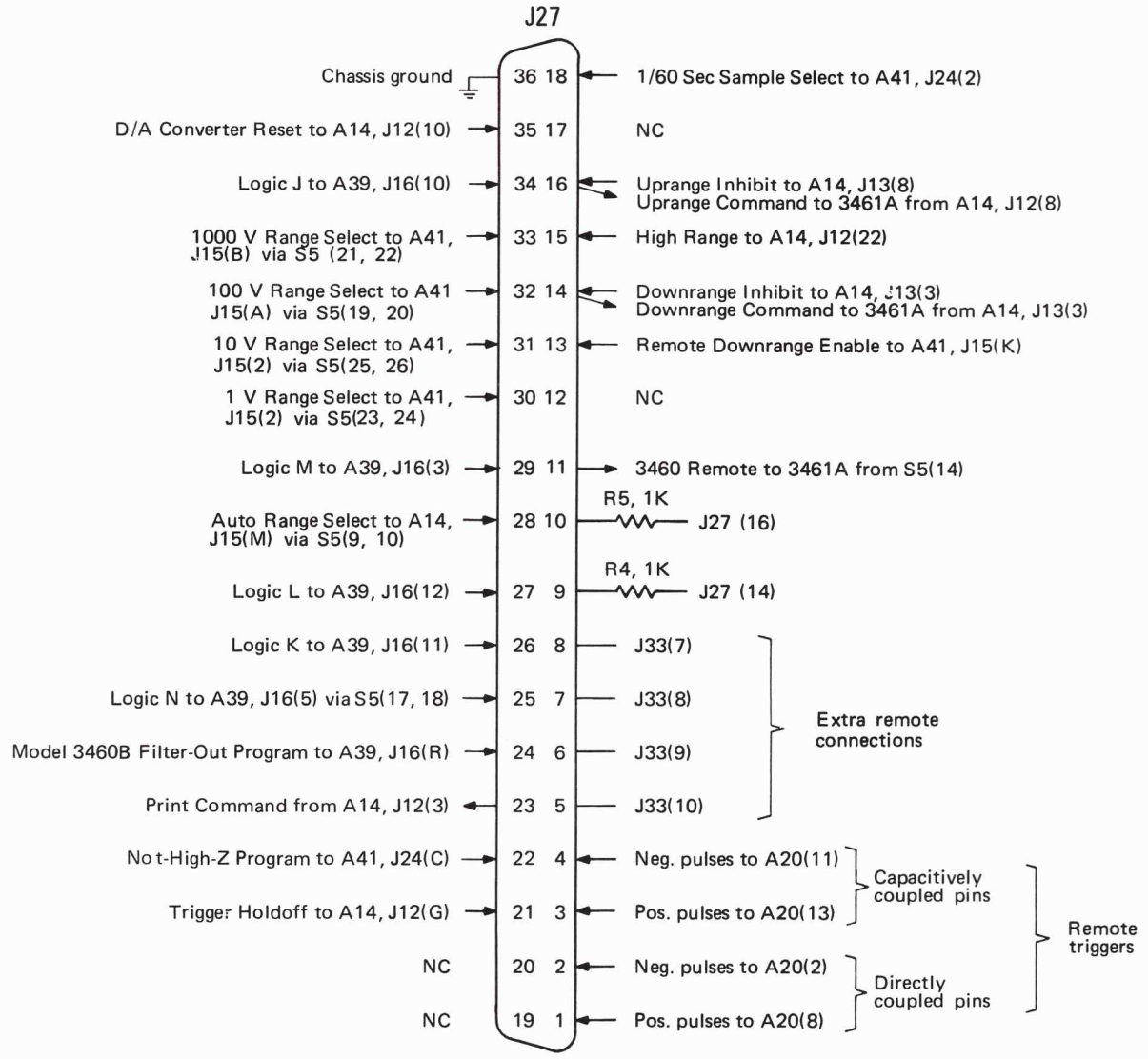
d. Depress REMOTE RANGE pushbutton.

NOTE

In the REMOTE mode of operation, the range may be controlled by the 1, 10, 100, 1000 or AUTO pushbuttons on the front panel if desired.

Table 3-1. Remote Control Cable Color Code

REMOTE CONTROL CONNECTOR PIN NO.	FUNCTION	WIRE COLOR
1	Pos Trigger	Wht
2	Neg Trigger	Wht/Blk/Yel
3	Pos Trigger	Vio
4	Neg Trigger	Wht/Blk/Gry
5	Extra remote connection	Gray
6	Extra remote connection	Green
7	Extra remote connection	Yel
8	Extra remote connection	Brn
9	NC	
10	NC	
11	NC	
12	NC	
13	NC	
14	NC	
15	NC	
16	NC	
17	NC	
18	1/60 Sec Sample Select	Wht/Blu/Gry
19	NC	
20	NC	
21	Trigger Holdoff	Wht/Grn/Vio
22	Not-High-Z Program	Wht/Red/Grn
23	Print Command	Wht/Brn/Grn
24	Filter-Out Program for Model 3460BF	Wht/Brn/Blu
25	NC	
26	NC	
27	NC	
28	Auto Range Select	Wht/Blk
29	NC	
30	1 V Range Select	Wht/Yel
31	10 V Range Select	Wht/Grn
32	100 V Range Select	Wht/Orn
33	1 kV Range Select	Wht/Brn
34	NC	
35	D/A Converter Reset	Wht/Blu/Vio
36	Chassis Ground	Blk



NOTES

1. Trigger pulses may be applied to pins 1 thru 4 to cause the 3460B to make new voltage measurements when the front-panel LOCAL/REMOTE switch is on REMOTE. See Table 3-4 for voltage, pulse duration, and current requirements of Triggers.
2. 3460B Remote, Downrange Command, and Uprange Command signals of pins 11, 14, and 16 are used by the -hp- 3461A AC/Ohms Converter-DC Preamplifier when the 3460B and the 3461A are operated as a system.
3. Remote Downrange Enable, Uprange Inhibit, Downrange Inhibit, High Range, and J, K, L, M and N are logic signals from the 3461A to the Automatic Range Selector A41 and the Converter Adaptor A39 of the 3460B.
4. Pin 18 may be shorted to chassis ground (pin 36) to select 1/60 sec samples, except on the 1 V range.
5. A voltage between +3 and +10 volts dc may be applied to pin 21 to "holdoff" local or remote triggers, thus preventing new readings.
6. Pin 22 may be shorted to chassis ground to reduce the input resistance of the 10 V and 1 V ranges from 10^{10} ohms to 10^{7} ohms.
7. A step voltage is received at pin 23 coincident with each reading period which may be used to synchronize a digital recorder or other auxiliary instrument. See Paragraph 3-51.
8. Pin 24 may be shorted to chassis ground to disable the Input Filter of the Model 3460BF.
9. Pin 28 may be shorted to chassis ground to select automatic ranging when the front-panel REMOTE RANGE switch is depressed.
10. Pins 30 thru 33 may be shorted to chassis ground to select a particular instrument range when the front-panel REMOTE RANGE switch is depressed.
11. Pin 35 may be shorted to chassis ground to insure a 1/60 sec 1st sample period that results when the D-toA Converter is now reset at the end of every reading period.

Figure 3-3. Remote Control Connection

3-18. Option 002, 003, 006 and 007 Operation.

3-19. Model 3460B Options 002, 003, 006 and 007 are used in conjuction with -hp- Model 3461A AC/Ohms Converter-DC Preamplifier. The operation of the above options is described in the following paragraphs. The Model 3461A manual outlines the accuracy specifications for ac and ohm measurements. Refer to the 3461A Operating and Service Manual for accuracy specifications, interconnection particulars, and detailed operating instructions of the 3461A-3460B system.

3-20. 3460B front panel settings:

a. Observe the necessary operation precautions listed in Paragraph 3-3.

b. Position LOCAL-REMOTE TRIGGERING Selector to LOCAL or REMOTE.

c. Depress REMOTE RANGE pushbutton, and position REAR-FRONT switch to REAR.

d. Connect the Interface Logic Cable supplied with 3461A between J54 of 3461A and J27 of 3460B.

e. Connect the Output Cable supplied with the 3461A between J53 of 3461A and J26 of 3460B.

3-21. In Option 002, 003, 006 and 007 operation, the 3461A automatically selects the actual measurement range of the 3460B as well as the readout range when a range selection is made at the 3461A. The logic signals J thru N select the readout range and the 1 V-Select thru 1000 V-Select signals accomplish the measurement range selection. Triggers and Trigger Holdoff are now applied to the Remote Control Cable of the 3461A; however, triggering rate may still be adjusted at the 3460B front-panel if desired. Short-1st-Sample and Short-2nd-Sample Program as well as Not-High-Z Program are also accomplished at the 3461A Remote Control Cable. The BCD is still monitored at the RECORDER Jack of the 3460B.

3-22. Delay of Measurement.

3-23. The 3460B Digital Voltmeter automatically delays each measurement of ac voltage as follows:

FUNCTION	DELAY
AC FAST	360 ms ± 36 ms
AC NORM	960 ms ± 96 ms

The delay permits proper operation of the Model 3461A.

3-24. 3460B INPUT CONNECTIONS.

3-25. Two sets of input connectors are provided, one set of binding post terminals on the front panel and a shielded connector on the rear panel. The REAR-FRONT INPUT switch connects either set of connections to the voltmeter input circuit. The two input connections are completely isolated (above 5000 megohms) from each other. Therefore, a voltage may be measured via the front panel binding posts with a voltage applied to the rear INPUT by simply positioning the REAR-FRONT switch to FRONT position.

3-26. REAR INPUT.

3-27. A six foot guarding preserved cable (-hp- Model 11065A) that mates with the rear INPUT connector (J26) is used for rear input measurements. The cable connections are identified on the 11065A connector. (Refer to Paragraph 3-30 for GUARD connections.)

3-28. FRONT INPUT.

3-29. The front panel input binding post terminals are constructed to accept plain wire leads, or leads terminated in banana plugs. For high voltages, and when there is little possibility of electrostatic or electromagnetic pickup, plain insulated-copper wire will suffice for input leads. For low voltages, and when there is a possibility of electrostatic or electromagnetic pickup, remove the GUARD-to-LOW shorting strap and use a shielded pair (see Figure 3-4) and connect one end of the shield to the GUARD INPUT binding post, and the other end to the LOW INPUT at point of measurement.

3-30. GUARD.

3-31. As a general rule, connect the LOW INPUT binding post to the side of circuit under measurement whose voltage is nearest to ground potential and the GUARD with shorting strap removed to the same point; however, some measurement conditions may call for connecting the GUARD to other points in the circuit under measurement. Refer to the discussion of guarding in Section IV for additional information.

3-32. Figure 3-4 shows some typical connections using the GUARD connection.

a. Floating Measurements. The GUARD and LOW connector must be shorted for a floating measurement. If a shielded two conductor cable like the one illustrated in Figure 3-4 is used, connect GUARD and LOW as shown in examples 1 and 2.

CAUTION

DO NOT CONNECT GUARD TO GROUND WHEN MEASURING A FLOATING VOLTAGE. IF 50 VOLTS OR MORE ARE APPLIED BETWEEN LOW AND GUARD, THE 3460B MAY BE DAMAGED.

b. Referenced Measurements. When the GUARD connection is used for measurements referenced to ground, connect the GUARD to ground. Examples 3 and 4 in Figure 3-4 show two typical connections for referenced measurements. If the GUARD connection is not used, connect the GUARD-to-LOW shorting bar.

CAUTION

WHEN MAKING REFERENCE MEASUREMENTS, DO NOT CONNECT THE GUARD TO ANY POINT WHERE THE POTENTIAL DIFFERENCE OF THE LOW AND GUARD INPUTS EXCEED 50 VOLTS AT ANY GIVEN TIME. OTHERWISE, DAMAGE TO THE 3460B MAY RESULT.

3-33. INPUT VOLTAGE RANGE.

3-34. Four pushbutton selected input ranges of 1, 10, 100, and 1000 volts are provided. With the 20% overranging capability of the 3460B, the maximum Digital Display is 1.19999, 11.9999, 119.999, and 1199.99 respectively. When the applied voltage is 20% above the voltage range selected, the OVERLOAD indicator will light and the digital display will usually indicate 120100. If two adjacent manual RANGE pushbuttons are depressed at the same time, the right-side button selects the range.

3-35. AUTOMATIC RANGING.

3-36. When the AUTO pushbutton is depressed, the voltmeter automatically selects the proper voltage range for any applied voltage below 1199.99 volts. Upranging occurs at 20% above full scale, downranging occurs at 1/10 of full scale. Range changes are made at a rate of 1 range per 33 ms. Open INPUT binding post results in automatic selection of the 1 volt range. During automatic ranging, the digital display will indicate the measured voltage only after the voltmeter is on the proper range.

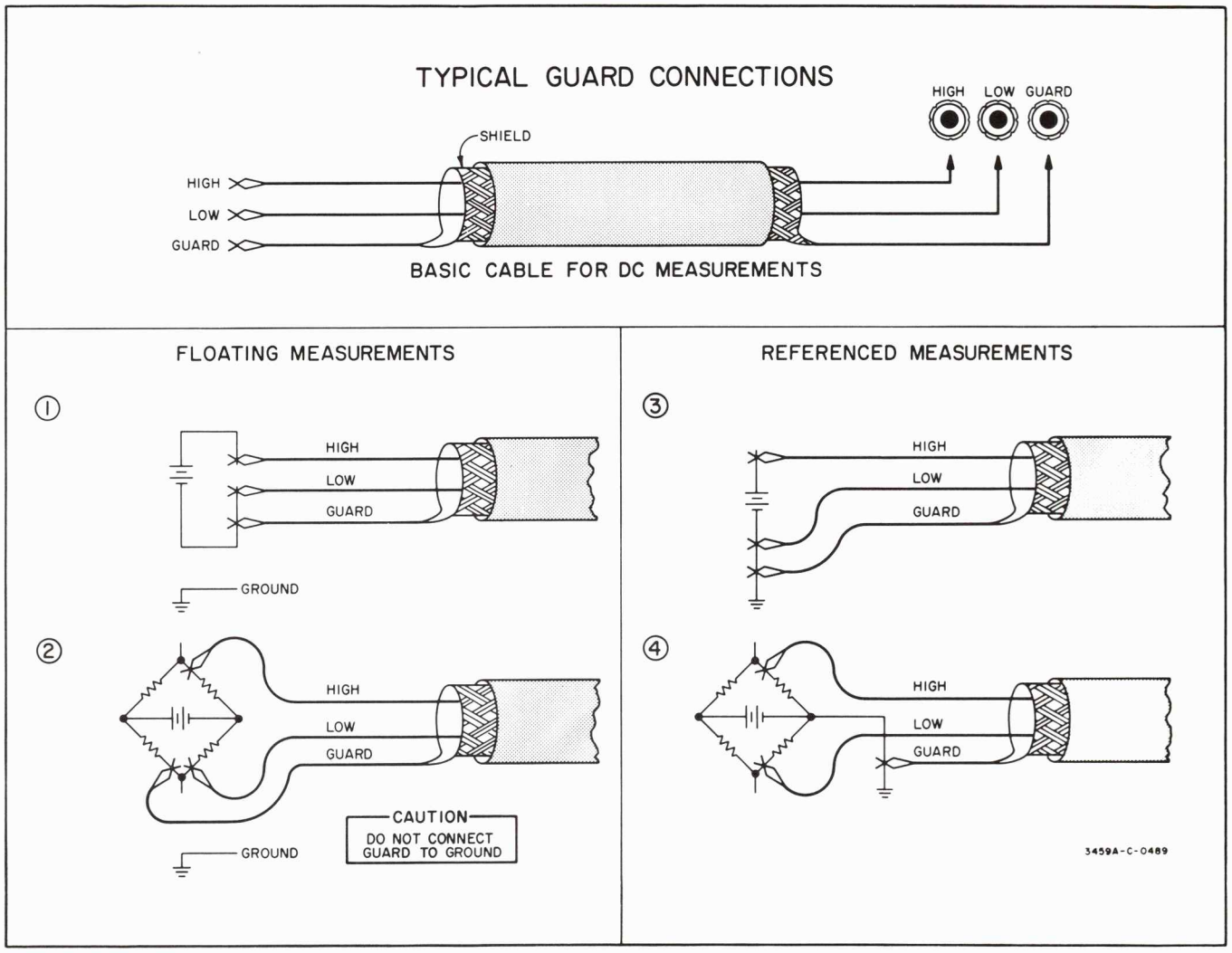


Figure 3-4. Typical Guard Connections

3-37. REMOTE RANGING.

3-38. Depressing the REMOTE RANGE pushbutton on the front panel enables remote control of the input voltage range. Automatic ranging or individual ranges may be selected by applying signals to pins on the REMOTE CONTROL connector (J27) on the rear panel as shown in Figure 3-3. Five connections on J27 receive simple switch closures having less than 100 ohms resistance to ground to select any of the ranges or automatic ranging. Individual range selecting signals applied to REMOTE CONTROL connector may be momentary or permanent. Automatic ranging is selected by a continuous switch closure to ground. The remote range selection signals must be applied at least 13 milliseconds before a new reading is initiated.

NOTE

Depressing the AUTO or any of the four manual range pushbuttons on the front panel establishes local control of range.

3-39. OVERLOAD.

3-40. The OVERLOAD indicator lights when the input voltage is higher than 1.2 times the range selected. It goes out as soon as the input voltage drops below the 20% overload voltage. No time is required for recovery after the overload condition is corrected. During overload, the display typically reads 120100 regardless of input voltage level and range selected. During an overload condition, the OVERLOAD indicator is not lighted during a reading period.

3-41. VOLTMETER READING RATE.

3-42. LOCAL MODE OF OPERATION.

3-43. A repetitive reading rate of 3/sec to 1/5 sec is obtained by adjusting the front panel TRIGGERING RATE control. Manual control of the reading rate is obtained by setting the TRIGGERING RATE control in HOLD position, and depressing the front panel TRIGGERING pushbutton to initiate each reading. The TRIGGERING pushbutton is also operative during repetitive readings but will not interrupt a reading period in process if depressed. Additional reading rates of 4/sec and 6/sec are obtained by grounding proper pin(s) on the REMOTE CONTROL connector on the rear panel to the voltmeter chassis as identified in Table 3-2. For the reading rates given in Table 3-2, the TRIGGERING RATE control must be adjusted for maximum reading rate (full cw).

3-44. The integration interval (second sample period) during LOCAL mode of operation is 1/10 sec, except, when pin 18 on the REMOTE CONTROL connector is grounded, the integration interval becomes 1/60 sec on the 10, 100, and 1000 volt ranges. The superimposed noise rejection for both integration intervals is shown in the graphs in Table 1-1.

3-45. REMOTE MODE OF OPERATION.

3-46. To initiate voltmeter readings in REMOTE mode of operation, refer to Figure 3-3 for the proper pin connections to the REMOTE CONTROL connector. The various reading rates for REMOTE mode of operation is

Table 3-2. Local Reading Rates

REMOTE CONTROL CONNECTION	RANGE	MAX READING RATE	MIN READING RATE	INTEGRATION INTERVAL
Pins 18 and 35 open	1 V 10 V 100 V 1000 V	4/sec to 3/sec if the input voltage level changes by more than 5% of full scale from the previous reading (see Note 1)	3/sec if the input voltage remains constant (see Note 2)	1/10 sec
Pin 35 grounded Pin 18 grounded	1 V	4/sec independent of input voltage changes	4/sec independent of input voltage changes (see Note 2)	1/10 sec
Pins 18 and 35 grounded	10 V 100 V 1000 V	6/sec independent of input voltage changes	6/sec independent of input voltage changes	1/60 sec

NOTE 1

IF THE INPUT VOLTAGE LEVEL REMAINS CONSTANT, THE READING RATE DECREASES.

NOTE 2

IF THE VOLTAGE BEING MEASURED PRODUCES ZERO PULSES (NULL) OUT OF THE V-TO-F CONVERTER, THE READING RATE DECREASES.

given in Table 3-3. The "Triggering Rate" identified in Table 3-3 is the number of triggers per second that must be applied to any of the four remote trigger lines (see Table 3-4) in order to obtain the "maximum reading rate" identified in Table 3-3. The superimposed noise rejection for both integration intervals identified in Table 3-3 is shown in the graphs in Table 1-1. A 1/60 sec integration interval is prohibited on the 1 volt range.

3-47. VERIFY READING RATE.

3-48. To verify the reading rate of the voltmeter, monitor the "Print command" signal at the REMOTE CONTROL connector pin 23 or RECORDER connector pin 23. The "Print command" signal will remain relatively positive (0 volts) for $\simeq$15 ms with the voltmeter reading at a max. rate of 15/sec.

3-49. REMOTE TRIGGERS.

3-50. The remote triggers for external programming of the reading rate when the front-panel LOCAL/REMOTE switch is on REMOTE can be either positive-going or negative-going voltage pulses applied at either capacitively coupled or directly coupled pins of the REMOTE CONTROL Jack J27. At pin 1, the pulses should have a base level of -10 volts and a peak level of 0 volts, with a period of at least 100 μ sec, but less than 10 msec. At pin 2, the base and peak levels should be +10 volts and -10 volts respectively, with a 100 μ sec-to-10 msec duration. At pins 3 and 4, pulses of 20 volts amplitude should be used, being positive-going at pin 3 and negative-going at 4, with a rise time of less than 10 μsec and a 100 μ sec duration. Remote triggers are "heldoff" and will not be effective until 15 msec after the Print Command signal is generated.

3-51. PRINT COMMAND.

3-52. Each time the voltmeter completes a reading, a "Print command" pulse is received at J27 pin 23 which can be used to program the next voltmeter reading, to step a scanning device, or to initiate a recording. The output "Print command" pulse cannot be fed into one of the remote trigger inputs to obtain a free-running system during the REMOTE mode of operation.

Table 3-3. Remote Reading Rates

REMOTE CONTROL CONNECTIONS	MAXIMUM READING RATE	REMOTE TRIGGERING RATE	INTEGRATION INTERVAL
Pins 18 and 35 open	7/sec if the input voltage level changes by more than 5% of full scale from the previous reading. NOTE IF THE INPUT VOLTAGE LEVEL REMAINS CONSTANT, THE READING RATE DECREASES.	7/sec	1/10 sec
Pin 35 grounded Pin 18 open	7/sec on all ranges independent of input voltage change between readings	7/sec	1/10 sec
Pin 18 grounded Pin 35 open	12/sec on the 10, 100, and 1000 volt ranges if the input voltage level changes by more than 1% of full scale from the previous reading. 7/sec on the 1 volt range if the input voltage level changes more than 5% of full scale. NOTE IF THE INPUT VOLTAGE LEVEL REMAINS CONSTANT, THE READING RATE DECREASES.	12/sec 7/sec on the 1 volt range	1/60 sec 1/10 sec on the 1 volt range
Pins 18 and 35 grounded	15/sec on the 10, 100, and 1000 volt range. 7/sec on the 1 volt range. Independent of input voltage changes between readings.	15/sec 7/sec on the 1 volt range	1/60 sec 1/10 sec on the 1 volt range

Table 3-4. External Triggering

REMOTE TRIGGERS AT J27	OPEN CKT VOLTAGE	TRIGGERING LEVEL	PULSE DURATION	CURRENT
Positive going at directly coupled pin 1.	- 10 V	0 Vdc	100 μsec to 10 ms	1 mA at 0 V 6 mA at +30 V
Negative going at directly coupled at pin 2.	+10 V	-10 Vdc	100 μsec to 10 ms	2 mA at -10 V 5 mA at -30 V
Positive going at capacitively coupled pin 3. Negative going at capacitively coupled pin 4.	---	20 V p-p with rise $\leq$10 μsec	$>$100 μsec	6 kilohms in parallel with 25 pF (0.01 μF coupling capacity used)

CAUTION

THE THE DC TRIGGERING PULSES (POSITIVE OR NEGATIVE) SHOULD NOT EXCEED 30 VOLTS, AND THE CAPACITIVELY COUPLED TRIGGERS SHOULD NOT EXCEED 200 VOLTS PEAK; OTHERWISE, DAMAGE TO THE TRIGGERING CIRCUITS ON THE A14 AND/OR A20 ASSEMBLIES WILL RESULT.

3-53. HOLDOFF.

3-54. To prevent initiation of voltmeter readings by the remote triggers (or during the LOCAL mode of operation), apply a voltage of between +3 and +10 volts at pin 21 on the REMOTE CONTROL connector.

3-55. DIGITAL RECORDER OUTPUT.

3-56. The Model 3460B digital display, decimal point location, polarity and overload indication are presented in four-line binary coded decimal (BCD) at RECORDER connection (J28) on the rear panel. A printer such as the -hp- Model 562A Digital Recorder may be used to record this data. The RECORDER connector on the rear panel accepts the cable supplied with the 562A Digital Recorder. The 562A Digital Recorder limits the reading rate of the 3460B to 5 per sec by applying a "trigger holdoff" signal to the 3460B through the J28 pin 22. See Recorder connections, Figure 7-30, for recorder output data.

Table 3-5. Input Impedance and Sample Length

J27 PINS 18 OR 35 GROUNDED	INPUT VOLTAGE CHANGE BETWEEN READINGS	RANGE AND SAMPLE PERIOD					
		1 V		10 V		100 V and 1 KV	
		1st Samp	2nd Samp	1st Samp	2nd Samp	1st Samp	2nd Samp
	< 5%	L*	L*	L*	L*	L	L
	> 5%	S	L*	S	L*	S	L
35	---						
18	< 1%	L*	L*	S*	S*	S	S
18	> 1% & <5%	L*	L*	S	S*	S	S
18	> 5%	S	L*	S	S*	S	S
18 35	---						

L = long (1/10 sec) sample; S = short (1/60 sec) sample.
Pin 35 is D-to-A Converter Reset; pin 18 is 1/60 Sec Sample Select.
* High input impedance (10^{10} ohms) on this sample if J27(22) is not grounded.

3-57. INPUT IMPEDANCE AND SAMPLE LENGTH.

3-58. Table 3-5 is a list of all reading-period sample-length combinations and input resistance levels resulting from input voltage changes and the grounding of pins 18 and 35 of the Remote Control Jack J27. An asterisk indicates a sample period during which the higher instrument input resistance of 10^{10} ohms will be initiated if J27 pin 22 is not grounded. With pin 22 grounded, the resistance is a constant 10^{7} ohms. A constant 10^{10} ohms is possible on either the 1 V range, with pin 35 not grounded and a voltage change between readings of less than 5%; or on the 10 V range with both pins not grounded and less than 5% change, or only pin 18 grounded and less than 1% change.

3-59. FILTERED OPERATION (Options 004, 005, 006 and 007).

3-60. In normal use, the 3460B filter is automatically switched in on all voltage ranges. On Option 006 and 007 instruments, however, with the 3461A set to AC NORMAL or AC FAST Functions, the 3460B filter is automatically programmed out by the 3461A.

3-61. PROGRAMMING OUT THE FILTER.

3-62. The filter may be manually programmed out on all functions and ranges by providing a contact closure between pin 24 (Filter Out Program) and pin 36 (Chassis Ground) of the rear panel REMOTE CONTROL Connector. The Remote Control Cable Assembly (Model 11085A) supplied with the instrument connects to the Remote Connector and can be used to provide the Filter Out contact closure. The white-brown-blue wire connects to pin 24; the black wire connects to pin 36.

SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. This section contains the theory of operation for the -hp- Model 3460B Digital Voltmeter. Included is digital voltmeter terminology, a discussion of technique used in the voltmeter, and an overall description. A discussion of detailed block diagrams as well as a detailed discussion of the more complex assemblies contained within the instrument are also included. The theory of operation given in this section is for both REMOTE and LOCAL modes of operation unless otherwise specified.

4-3. DIGITAL VOLTMETER TERMINOLOGY.

4-4. Some of the terminology used in the discussion of this voltmeter is defined as follows:

a. Reading Period: the period of time from the command to digitize (trigger pulse) to the initiation of a "Print command." At the end of a reading period, all the counts contained in the Counting Units are transferred to the front panel digital display. One reading period includes two sample periods. Refer to discussion of the Timing and Control Assembly for additional information on reading period.

b. Reading Rate: the number of complete readings per period of time.

c. Triggering Rate: the number of triggers initiating readings per period of time.

d. Sample: the period of time the first or second sample gate is enabled and/or opened.

e. Integration Interval: duration of the second sample period (1/10 or 1/60 sec).

f. Enable: a signal that permits a command signal to generate a function.

g. Inhibit: a signal that prevents a command signal from generating a function.

h. Command: a gated signal that generates a function.

i. Open Gate: passes a command.

j. Closed Gate: blocks a command.

k. Select: a gated or ungated signal that controls a switch and/or relay closure. A select signal is also generated by manual switch closure.

m. Function: an operation or purpose of an assembly, circuit, or component. A function may be gated or selected by a switch or relay closure.

4-5. LOGIC SYMBOLOGY.

4-6. Some of the circuits in the -hp- Model 3460B are explained in terms of logic symbology (AND Gates, OR Gates, etc.). All the basic information required to understand the logic symbology discussed in this section is given in Table 4-1.

4-7. The -hp- Model 3460B uses both negative true and positive true logic. The levels of both negative true and positive true logic are as follows:

a. Negative true logic: True = -15 to -35 volts
False = 0 to -3 volts

b. Positive true logic: True = 0 to -3 volts
False = -15 to -35 volts

4-8. TECHNIQUE.

4-9. The 3460B is an integrating potentiometric type digital voltmeter which uses two precise sample periods per reading. During the first sample period, the four most significant digits of the input voltage are measured. During the second sample, a difference voltage between the input voltage and a voltage equivalent to the voltage measured during the first sample period (D-to-A voltage) is measured for the fifth and sixth digits of the input voltage. The fifth and sixth digits are the least significant digits of the voltmeter. The second sample period is a measurement of the difference between the D-to-A voltage and the actual input voltage. Both the first and second sample period measurements may be made with an accuracy of up to 0.2% and still maintain the 0.004% ±2 counts specified accuracy of the voltmeter. An example of the two-sample period technique is given in the following paragraph.

4-10. TWO SAMPLE PERIOD TECHNIQUE.

NOTE

This example assumes a -0.2% error for both the first and second sample periods.

Input voltage to be measured	. . .	1.01935 volts
Counts entered into first four digits during first sample period	. . .	1016 (-0.2% error, and -1 count counter uncertainty)*

Table 4-1. Logic Symbology

1 indicates true signal.

0 indicates false signal.

→ indicates direction of signal flow.

○ on symbol indicates logical inversion (not necessarily electrical) of the input or output signal(s). The logic indicated with the symbol remains the same.

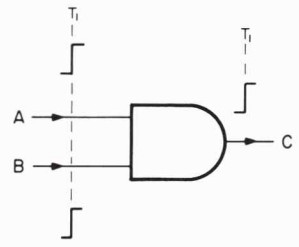
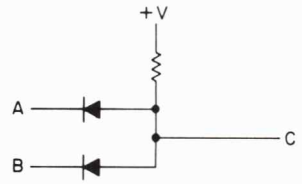
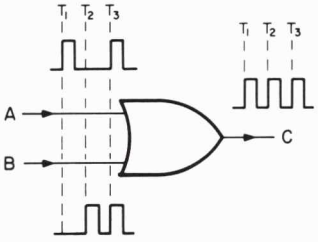
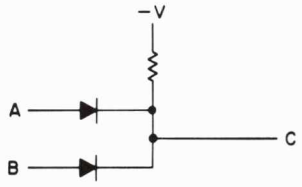
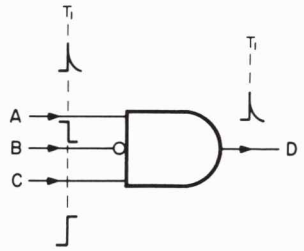
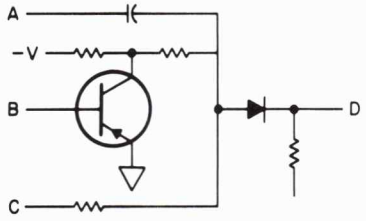
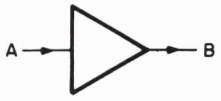
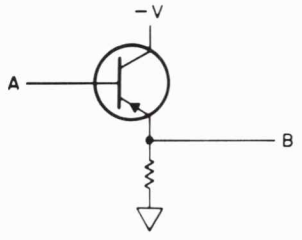
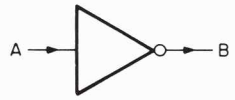
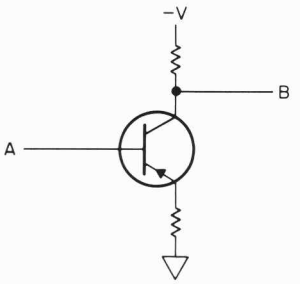
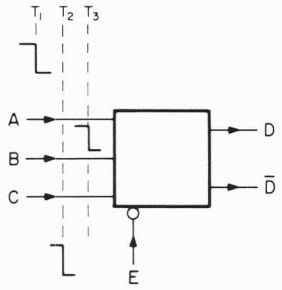
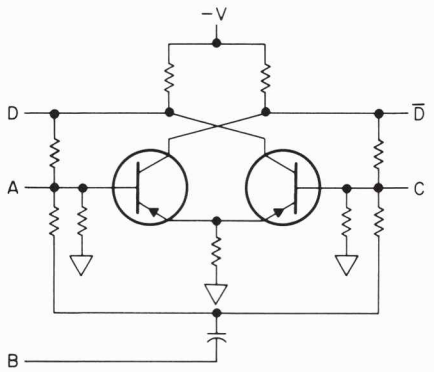
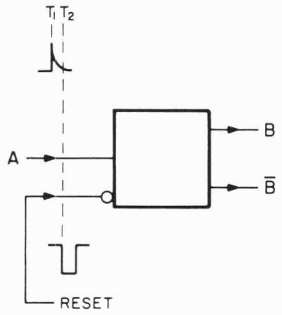
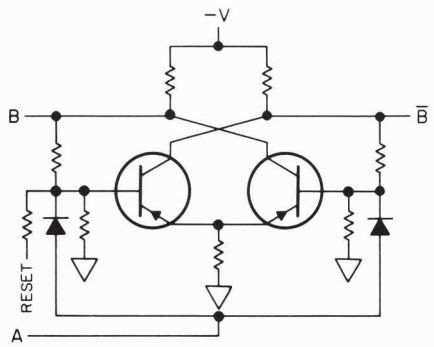
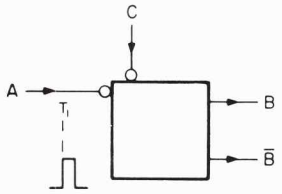
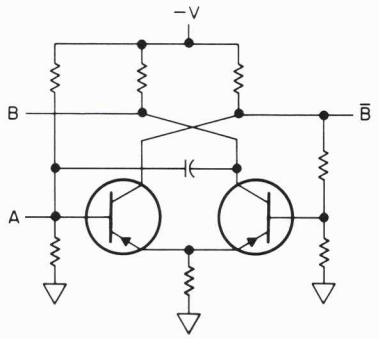
Desig.	Logic Symbol	Description	Truth Table	Typical Circuit
AND Gate (Positive True)		Both input signals (A and B) must be true simultaneously to produce a true output at C.	A B C 0 0 0 0 1 0 1 0 0 1 1 1	
OR Gate (Positive True)		If either input signal (A or B) or both is true, the output at C is true.	A B C 0 0 0 0 1 1 1 0 1 1 1 1	
Multiple Input Gate (Positive True)		Any combinations of inputs may be used with an AND or OR Gate to obtain a desired output. In the AND Gate shown, input B is inverted, and inputs A and C are without inversion. Inputs A and C must both be true, and input B must be false simultaneously to produce a true output at D.	A B C D 0 0 0 0 0 0 1 0 0 1 0 0 0 1 1 0 1 0 0 0 1 0 1 1 1 1 0 0 1 1 1 0	
Time Delay		Input signal delayed by the time indicated. True input at A produces a true output at B after a 15 ms delay.	— —	
Amplifier		True input at A produces amplified true output at B. An amplifier will function with either positive true or negative true signals.	— —	

Table 4-1. Logic Symbology (Cont'd)

Desig.	Logic Symbol	Description	Typical Circuit
Inverter Amplifier		True input at A produces false output at B, and false input at A produces a true output at B (inverts the input logic level).	
Flip-Flop		Outputs D and $\overline{D}$ are always in opposite states -- if D is true, $\overline{D}$ is false. A true input will cause the output directly across to go true -- true input at A sets output D true. With no input, the flip-flop remains in the state set by the last input signal. A true input at B will cause the flip-flop to reverse state. A true input at the direct reset input E holds the flip-flop in the $\overline{D}$ true state.	
Binary		The binary is a flip-flop which changes state with every true input pulse at A. Since A is applied to the bases of both transistors, it is shown centered in the symbol. The negative pulse produces the same effect as a positive pulse applied to the opposite base. To preserve the positive logic, the reset pulse is shown inverted and applied to the opposite side. A reset pulse sets $\overline{B}$ true.	
One-Shot		True input at A sets the one-shot to unstable state (active) and produces a true output at B. In the symbol shown, the A input must be false (positive) with respect to negative true logic of the one-shot. During the stable state, the $\overline{B}$ output is true. A true input at C (direct set) holds the one-shot in the unstable state.	

D-to-A Voltage	. . .	1.01600 volts**
Difference Voltage	. . .	0.00335 volts
Counts entered into last two digits of voltmeter during second sample period	. . .	333 (-0.2% error, and -1 count counter uncertainty)*
Counts entered in first four digits (most significant digits)	. . .	1016
Counts entered in last two digits (least significant) digits)	. . .	333
Resultant total counts	. . .	101933
Digital display in volts measured with decimal point	. . .	1.01933 volts

*worst case
** assumed perfect D-to-A Conversion

4-11. OVERALL DESCRIPTION.

4-12. The simplified block diagram of the 3460B Digital Voltmeter, illustrated in Figure 4-1, is divided into three sections – Voltage-to-Frequency Converter, Counting Units, and Digital-to-Analog Converter. Paragraphs 4-13 through 4-21 give functions of each section and discuss overall theory of operation for the complete instrument.

4-13. VOLTAGE-TO-FREQUENCY CONVERTER.

4-14. Function of the V-to-F Converter is to generate pulses at a rate proportional to its input voltage.

4-15. COUNTING UNITS.

4-16. Function of the Counting Units is to count the proportional pulses generated by the V-to-F Converter during precise time intervals, and to separately store and display the total count.

4-17. DIGITAL-TO-ANALOG CONVERTER.

4-18. Function of the D-to-A Converter is to produce an accurate dc voltage equivalent to the counts stored within the first four Counting Units during the first sample period.

4-19. OVERALL THEORY.

4-20. The unknown input voltage is continually applied through the input attenuator to the V-to-F Converter where it is converted into pulses whose frequency is proportional to the input voltage. During the first sample period, the first sample gate opens and allows the first four Counting Units to count the pulses generated by the V-to-F Converter for 1/60 sec. During the first sample period, the D-to-A Converter generates zero volts. At the end of the first sample period, the total counts in the first four Counting Units are stored, and equivalent counts are supplied to the D-to-A Converter where they are converted to an analog signal equal to the V-to-F Converter input voltage during the first sample period.

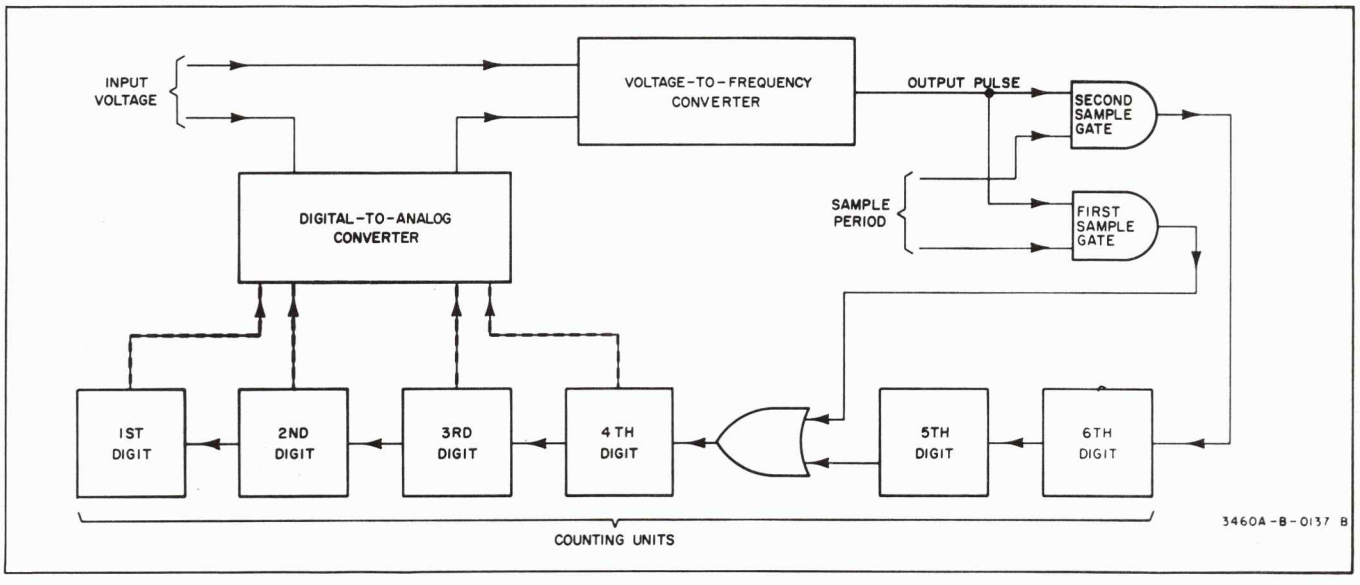


Figure 4-1. Simplified Block Diagram

4-21. The D-to-A Converter output voltage is fed back in series with the V-to-F Converter input, and tends to create a null. The difference and/or error voltage between the input voltages and the D-to-A voltage is applied to the V-to-F Converter and converted into a frequency proportional to the difference and/or error voltage. The pulses generated by the difference voltage are counted by the fifth and sixth digit Counting Units through the second sample gate during the second sample period. If the pulses counted during the second sample period exceed 99, the count contained within the first four Counting Units is changed accordingly. At the end of the second sample period, a "neon transfer" command transfers counts contained in all Counting Units to the display tubes for a front panel digital display indication directly in volts measured.

4-22. DETAILED BLOCK DIAGRAM.

4-23. Figure 7-2 illustrates a Detailed Block Diagram of the Model 3460B. Each block of the diagram is discussed in the following paragraphs.

4-24. GENERAL.

4-25. The circuits of the Voltage-to-Frequency Converter, and the Digital-to-Analog Converter, along with the Reference Power Supply, are mounted within the voltmeter Guard Assembly as shown in Figure 7-2, Detailed Block Diagram, and in Figure 7-1, Assembly Location Diagram. The guard is completely insulated (above 10^9 ohms) from the main chassis of the voltmeter. The assemblies within the Guard Assembly are also completely insulated (above 10^9 ohms) from the guard.

4-26. Each of the three power supplies within the Guard Assembly is separately referenced to the common point of the circuit to which it supplies power. The common point for the Voltage-to-Current Converter (A5) is indicated by ▽1. The common point of the Integrator (A1) and the Precision Current Pulse Generator (A2) is indicated by ▽2. The Reference Power Supply (A19) is referenced to the LOW INPUT terminal ▽3 through an appropriate polarity relay on the D-to-A Relay Assembly (A21). The common points ▽1 and ▽2 are connected to the LOW INPUT terminal common point ▽3 through the Sensitivity Resistors and/or the Digital-to-Analog Resistor Assembly.

4-27. INPUT ATTENUATOR.

4-28. The voltage to be measured is applied through the Input Attenuator to the Voltage-to-Frequency Converter. The 10 megohm Input Attenuator with attenuation settings of 1, .1, .01, .001 and .0001 is controlled by five Range Selector Relays on the Input Range and Sensitivity Selector Assembly (A43). The proper relays are energized by command signals from the Auto Range Selector (A41) according to the sample period, range selected and sensitivity control signals from Timing and Control Assembly (A14). The Input Attenuator setting changes between the first and second sample periods. The Input Attenuator settings for both the first and second sample period, per range, are given in Table 4-2. Each tap on the Input Attenuator is coupled through a relay contact to the input of the Voltage-to-Current Converter within the V-to-F Converter. The bottom of the Input Attenuator is connected to the LOW input terminal, common point ▽3.

Table 4-2. Range and Amplifier Sensitivity Logic

RANGE SELECTION A41		SENSITIVITY						
		FIRST SAMPLE PERIOD Selected by low sensitivity (E)			SECOND SAMPLE PERIOD Selected by high sensitivity (E)			
							TRANSCONDUCTANCE	
							1/60 sec SAMPLE	1/10 sec SAMPLE
RANGE	A41 BINARIES SELECTED BY RANGE SWITCH	INPUT ATTENUATOR SETTING	INPUT ATTENUATOR SETTING SELECTED BY (NEGATIVE TRUE)	TRANSCONDUCTANCE (333 ohms)	INPUT ATTENUATOR SETTING	INPUT ATTENUATOR SETTING SELECTED BY (NEGATIVE TRUE)	REMOTE MODE PROGRAMMED BY GROUNDING PIN 18 OF J27 (SEE FIG. 3-3)	LOCAL MODE; SELECTED BY: E (A B + 1/60 sec)
1	$\overline{A}\,\overline{B}$	0.1	E $\overline{A}\,\overline{B}$	3000 μ mho	1	$\overline{E}\,\overline{B}$	Prohibited	5000 μ mho (200 ohms)
10	A $\overline{B}$	0.01	E A $\overline{B}$	3000 μ mho	1	$\overline{E}\,\overline{B}$	3000 μ mho (333 ohms)	500 μ mho (2000 ohms)
100	$\overline{A}$ B	0.001	E $\overline{A}$ B	3000 μ mho	0.1	$\overline{E}\,\overline{A}$ B	3000 μ mho (333 ohms)	500 μ mho (2000 ohms)
1000	A B	0.0001	E A B	3000 μ mho	0.01	$\overline{E}$ A B	3000 μ mho (333 ohms)	500 μ mho (2000 ohms)

4-29. A50 INPUT FILTER, RANGE AND SENSITIVITY SELECTOR (Options 004, 005, 006, 007).

4-30. A50 contains the 3460B RC filter and filter switching relays in addition to the Input Range and Sensitivity Selector circuits normally located on the 3460B A43 assembly.

4-31. The RC filter consists of A50C1 and A50C2 in conjunction with A50R1 through A50R12 and A50R26 and A50R27. A50K11 selects A50C1 350 msec before the beginning of a sample period and stays energized until the end of the sample period. When A50K11 de-energizes at the end of the sample period, A50C1 discharges through A50R29. The A50K11-A50C1 filter operates during all Sample Periods except when the 0.1 Attenuator setting is selected by A50K2. When the 0.1 Attenuator setting is selected, A50K12 switches in 350 msec before a sample period until the end of the sample period. After the sample period, A50K12 de-energizes, allowing A50C2 to discharge through A50R30. Two filter capacitors and two filter relays are necessary in order to achieve a uniform RC time constant with the changing resistance of the A50 Range Selector as different attenuator settings are selected by A50K1 through A50K5.

4-32. The RC time constant of the filter is approximately 50 msec regardless of the attenuator setting. The filter is switched in 350 msec before the sample period begins by A50K11 or A50K12, allowing the filter to charge to the value of the input to the DC Amplifier (A5) before beginning the measurement. This prevents errors in the 3460B reading that would result if the sample period occurred during the filter charge time. The filter is switched out between samples to prevent errors caused by transients which occur during D-to-A transfer.

4-33. In the Option 004, 005, 006 and 007 instruments, A50 replaces the 3460B A43 assembly of the Standard, Option 001, 002 and 003 instruments.

4-34. A47 FILTER ENABLE ASSEMBLY.

4-35. A47 contains the Filter Enable, T Inverter and Sample Delay Switch circuits in addition to the Printer Bias resistors normally located on the 3460B A45 assembly.

4-36. The Filter Enable circuit drives the filter relay coils, A50L11 and A50L12. A47Q1 energizes A50K11 which switches in the 0.33 μ F filter; A47Q2 energizes A50K12 which switches in the 0.056 μ F filter.

4-37. A42 provides a conduction path (Filter Enable) for A47Q1 and A47Q2 from 350 msec before the Sample Period begins until the end of the Sample Period. During this time (for all except the 0.1 attenuator setting on A50) A47Q1 conducts and switches in the 0.33 μ F filter, A50C1. When the Sample Period ends, A47Q1 turns off and the 0.33 μ F filter discharges. When an 0.1 attenuator setting is selected by A50K2, A47Q1 is turned off and A47Q2 conducts, switching in the 0.056 μ F filter, A50C2, from 350 msec before the Sample Period until the Sample Period ends.

4-38. The T Inverter (A47Q2) provides T to the Sample Delay Circuit (p/o A42). The Sample Delay Switch (A47Q4) disables the Sample Period Flip-Flop (A17Q1 and A17Q2) until 350 msec after one of the A50 filters is switched in.

4-39. In the Option 004, 005, 006 and 007 instruments A47 replaces the 3460B A45 assembly in the 3460B Standard, Option 001, 002 and 003 instruments.

4-40. VOLTAGE-TO-FREQUENCY CONVERTER.

4-41. The Voltage-to-Frequency Converter includes the Voltage-to-Current Converter (A5), Sensitivity Resistors, Integrator (A1), Precision Current Pulse Generator (A2), Plus and Minus 25 Volt Power Supply (A4), and the Plus and Minus 17.5 Volt Power Supply (A3). The function of the Voltage-to-Frequency Converter is to generate pulses at a rate proportional to its input voltage. Figure 4-2, Voltage-to-Frequency Conversion, shows the operation of the V-to-F Converter for two different levels of input voltage.

4-42. Voltage-To-Current Converter.

4-43. The V-to-C Converter is an operational amplifier with unity gain and a bandwidth of approximately 1 megacycle. The V-to-C Converter is equivalent to a cathode follower with the Sensitivity Resistor(s) being the cathode load. The function of the V-to-C Converter is to generate an output current that is proportional to its input voltage as shown in Figure 4-2. The total input voltage to the V-to-C Converter is developed across the Sensitivity Resistor or Resistors selected. The output current of the V-to-C Converter is equal to the input voltage divided by the selected value of Sensitivity Resistor(s) selected. The V-to-C Converter is powered by the Plus and Minus 25 Volt Power Supply (A4) which is referenced to the V-to-C Converter common point ∇. A more detailed description of A5 can be found on Page 7-6.

4-44. Sensitivity Resistors.

4-45. The Sensitivity Resistors are located on the Input Range and Sensitivity Selector Assembly (A43). With the input voltage developed across the 200 ohm resistor, the effective transconductance of V-to-C Converter is 5000 micromhos. With the input voltage developed across the 200 and 133 ohm resistors, the transconductance is 3000 micromhos. With the input voltage developed across the 200, 133, and 1666 ohm resistors, the transconductance is 500 micromhos. The 3000 micromhos condition is used for all input voltage ranges during the 1/60 sec sample period; the 5000 micromho condition is used only on the 1 volt range during the second sample period (1/10 sec); the 500 micromho condition is for all other voltage ranges during

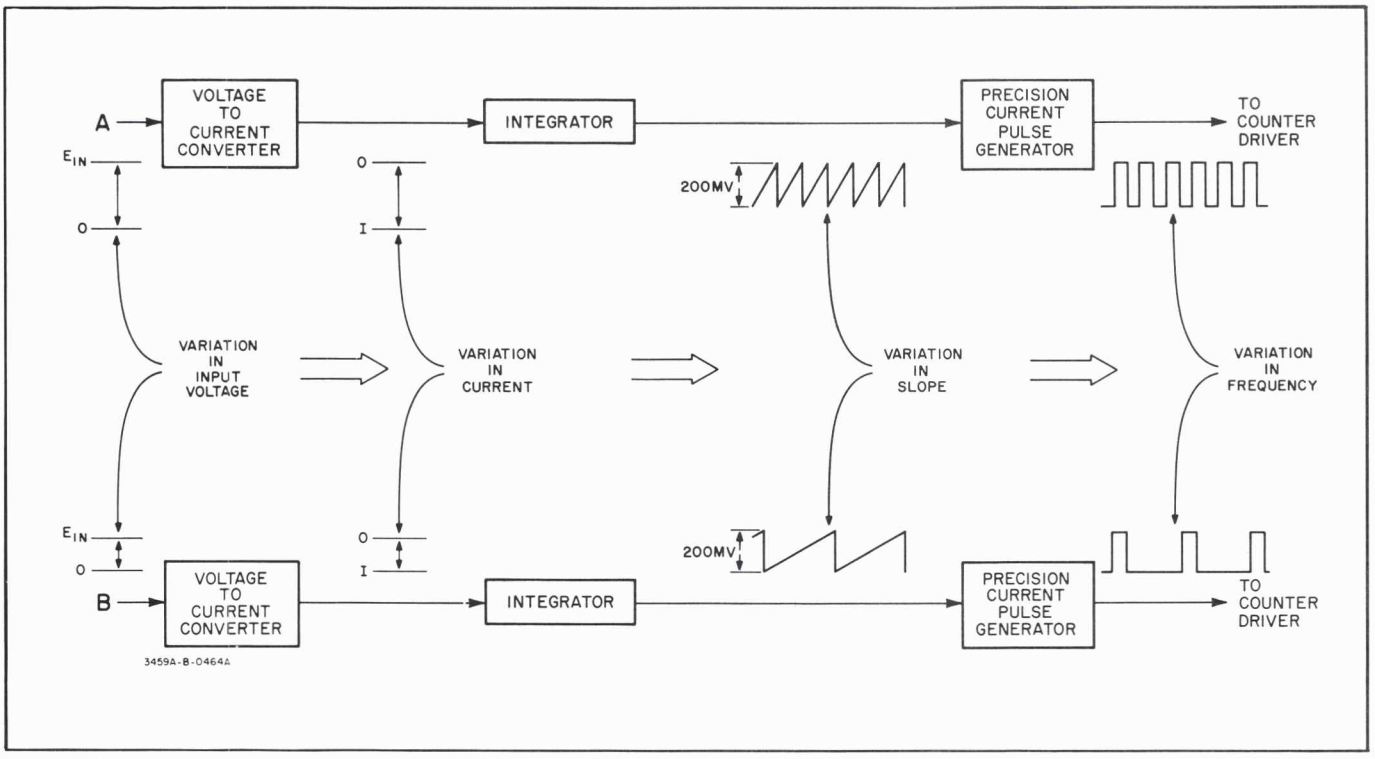


Figure 4-2. Voltage-to-Frequency Conversion

the 1/10 sec sampling period. Transconductance setting for each sample period and range selected is given in Table 4-2. For each Sensitivity Resistor selected there is a corresponding reed relay closure on the Sensitivity Selector Assembly. Sensitivity Selector Relays are energized by "transconductance select" signal from the Auto Range Selector Assembly (A41). The level of output current from the V-to-C Converter as determined by the Sensitivity Resistor(s) is applied to the Integrator Assembly (A1).

4-46. Integrator.

4-47. The Integrator Assembly (A1) is an inverting amplifier having a dc voltage gain of approximately 4000 and an Integrating Capacitor (A1C6) connected between the input and output. The current applied to the input will cause the Integrating Capacitor to charge in such a manner as to produce a positive going ramp with positive voltage applied to the voltmeter input (HIGH INPUT binding post positive with respect to LOW) and a negative going ramp with negative voltage applied to the voltmeter input. The slope of the ramp will be proportional to the magnitude of the input current as illustrated in Figure 4-2.

4-48. If the input voltage is positive, a negative current is fed to the Integrator and the Integrator output will be a positive going ramp. If the input voltage is negative, a positive current is fed to the Integrator, and the Integrator output will be a negative going ramp. The output of the Integrator is applied to the Precision Current Pulse Generator Assembly (A2).

4-49. Precision Current Pulse Generator.

4-50. The Precision Current Pulse Generator Assembly (A2) contains two detectors and two pulse generators. The two detector circuits are essentially identical, except one is triggered by a positive going ramp (positive input voltage) while the other is triggered by a negative going ramp (negative input voltage). The two pulse generator circuits are also identical with the same exceptions. The ramp developed by the Integrator is detected by the negative or positive level detectors. When the ramp voltage reaches approximately 200 millivolts, the pulse generator will supply a "current pulse" to the input of the Integrator. The "current pulse" will oppose the current developing the ramp voltage and return it toward zero. This cycle repeats for each ramp developed by the Integrator, and a negative or positive sawtooth whose frequency is proportional to the input current is produced at the output of the Integrator. Each sawtooth developed is detected by the positive or negative detector and converted to a square pulse that is transformer coupled through the guard shield to the Counter Driver Assembly (A16). The (+) transformer receives the pulses produced by the positive detector, and the (-) transformer receives the pulses produced by the negative detector. The output of both transformers are positive pulses whose frequency is proportional to the input voltage. The Integrator and the Precision Current Pulse Generator are powered by the Plus and Minus 17.5 Volt Power Supply (A3).

4-51. The complete operation of V-to-F Converter section of voltmeter is expressed mathematically as follows:

$$F = Gm\ Ei\ K$$

where:

F = output of V-to-F Converter in pulses per second
Gm = transconductance of Voltage-to-Current Converter selected by Sensitivity Resistor(s) settings (see Table 4-2).
Ei = input voltage to Voltage-to-Current Converter.
K = 200 x 10 (5 nanoamps per pulse per second).
K is a constant current of 5 nanoamps/sec flowing into or out of the V-to-C Converter per each pulse produced.

4-52. FIRST SAMPLE GATE.

4-53. The positive pulses from the (+) or (-) transformer are applied through an OR Gate (CR25 and CR26) on the Counter Driver Assembly (A16). The output of the OR Gate is applied to a pulse shaper circuit (Q16 and Q17) where the pulses are converted to 5 μ sec pulses compatible with the counters. The pulses from the pulse shaper are applied to one input of the first sample 3-input AND Gate (CR13).

4-54. Another input to the first sample AND Gate is received from the sensitivity control portion of the Timing and Control Assembly. With the first application of voltage to be measured, a "low sensitivity" signal is programmed by Timing and Control and applied to the first sample gate (CR11). The programming of "low sensitivity" signal is controlled by the max count rate detector on the Counter Driver Assembly and circuits within the Timing and Control Assembly.

4-55. A "count gate enable" signal from the Sample Period Generator (A17) is applied to the remaining input of the first sample gate (CR16) initiating the first sample period. The first sample gate is held open by the "count gate enable" signal for precisely 1/60 sec; during this period of time, the pulses from the Voltage-to-Frequency Converter are fed through the first sample gate and an OR Gate (CR17) to the input of fourth digit Counting Unit. For the first sample period, the "count gate enable" signal is generated by the "1/60 sec select" signal from the Auto Range Selector and the "sample enable" signal from the Timing and Control Assembly.

4-56. The total number of pulses passed by the first sample gate are counted by the fourth, third, second and first digit Counting Units. The total number of pulses counted is obtained by multiplying "F" given in Paragraph 4-51 by the sample period (1/60 sec).

4-57. DIGITAL-TO-ANALOG CONVERSION.

4-58. At the end of the first sample period, the Timing and Control Assembly generates a "D-to-A transfer and reset" command. Upon receipt of "D-to-A transfer and reset" command the counts within the first four Counting Units are transferred to respective storage binaries within the Counting Units. The storage binaries store the counts in the first four Counting Units and drive the relays on the D-to-A Relay Assembly with "digital feedback" as illustrated on the Detailed Block Diagram. The "digital feedback" is in BCD code and becomes the input to the D-to-A Converter.

4-59. The "digital feedback" energizes reed relays on the D-to A Relay Assembly. An extremely accurate analog voltage (typically ±0.0015%) generated by the Reference Power Supply (A19) is applied through the contacts of the energized relays to precision resistors on the D-to-A Resistor Assembly. Within the D-to-A Resistor Assembly, the reference voltage is converted to an analog voltage equivalent to the stored count in first four Counting Units. The D-to-A output voltage is referenced directly to the LOW INPUT terminal, and its output polarity is controlled by the polarity control section of the Counter Driver Assembly in conjunction with the polarity of the input voltage.

4-60. SECOND SAMPLE GATE.

4-61. The D-to-A Converter output voltage is compared to the output of Input Attenuator, and the difference voltage is applied to the V-to-F Converter. The V-to-F Converter converts the difference voltage into pulses in the same manner described in Paragraphs 4-40 thru 4-51. The output of the V-to-F Converter is applied to the Counter Driver Assembly where the operation is similar to the first sample period. The positive pulses from the (+) or (-) transformer are applied through the OR Gate (CR25 and CR26) to the pulse shaper circuit (Q16 and Q17). The pulses from the pulse shaper are applied to one input of the second sample 3-input AND Gate (CR14). The Second Sample period is initiated by the "count gate enable" signal from the Sample Period Generator (CR15) and the existence of a "high sensitivity" signal from Timing and Control Assembly (CR12). The second sample gate is held open by the "count gate enable" signal for 1/10 sec (integration interval) except when programmed for 1/60 sec integration interval on the 10, 100, and 1000 volt range by grounding pin 18 on the REMOTE CONTROL connector. See Section III for integration interval during both LOCAL and REMOTE modes of operation.

4-62. For a 1/10 sec second sample period, the "count gate enable" signal is generated by the "1/10 sec sample select" signal from the pulse shaper, the absence of a "1/60 sec sample select" signal from the Auto Range Selector Assembly, and a "sample enable" signal from the Timing and Control Assembly. For the 1/60 sec second sample period, the "count gate enable" signal is generated by the "1/60 sec select" and the "sample enable" signals.

4-63. The total number of pulses passed by the second sample gate are counted by the fifth and sixth digit Counting Units. The total number of pulses counted during the second sample may also be obtained by multiplying "F" given in Paragraph 4-40 by the sample period. If the pulses counted during the second sample period exceed 99, a carry pulse or pulses is entered into the fourth digit Counting Unit.

4-64. NEON TRANSFER.

4-65. At the end of the second sample period, a "neon transfer" command is received from the Timing and Control Assembly. This command enables a transfer of counts contained in all Counting Units to the display tubes for a front panel digital display indication directly in volts measured. When the "neon transfer" command is terminated, the front panel digital display indication remains until another "neon transfer" command is received.

4-66. The "neon transfer" command completes one reading period; however, the Timing and Control Assembly continues to initiate readings at a rate adjustable by the front panel TRIGGERING RATE control in LOCAL mode or by external triggering in REMOTE mode of operation.

4-67. MAX COUNT RATE DETECTION.

4-68. If the input voltage level changes by more than the percentage identified in Tables 3-2 and 3-3, the max count rate detector on the Counter Driver Assembly generates a "max count rate detection" signal. The "max count rate detection" signal is applied to the Timing and Control Assembly to program a "low sensitivity" (E) signal for the first sample period. Each time a "low sensitivity" signal is programmed, the D-to-A Converter output voltage and all the Counting Units are reset to zero. With pin 35 on the REMOTE CONTROL connector grounded, a "low sensitivity" signal is programmed each time a "neon transfer" signal is generated. The presence of the "low sensitivity" signal is independent of input voltage change when programmed by the "neon transfer" signal.

4-69. If the input voltage remains constant between reading periods, the sensitivity control portion of the A14 Assembly generates a "high sensitivity" ($\overline{E}$) signal for both the first and second sample periods. With a "high sensitivity" signal during the first sample period, the "digital feedback" remains constant; that is, the D-to-A Converter is not reset to zero and the "digital feedback" changes the D-to-A Converter output voltage only if there is a change in the first four Counting Units. During this condition, the pulses generated by the V-to-F Converter, during both the first and second sample periods, are applied to the input of the sixth digit Counting Unit through the second sample gate and counted by all Counting Units. The first sample period actually becomes a second sample period, and the second sample gate opens twice in order to complete the reading.

4-70. With pins 18 and 35 on the REMOTE CONTROL connector open in both the LOCAL and REMOTE modes of operation, both sample periods are 1/10 sec with a constant input voltage until a "max count rate detection" signal is received from the Counter Driver Assembly.

4-71. RANGE AND SENSITIVITY CONTROL.

4-72. The range and sensitivity of the Model 3460B Voltmeter is controlled by reed relays on the INPUT Range and Sensitivity Selector (A43). The reed relays are energized by "transconductance select" and "Input attenuator select" signals from the Auto Range Selector (A41).

4-73. During the first sample, the pulses generated by the V-to-F Converter are applied to the fourth digit Counting Unit. Consequently, each count represents 100 counts of the total display. Therefore, the incoming signal has an attenuation ratio of a 100 between the first and second sample periods. For example, during the first sample on the 10 volt range, the input voltage is attenuated by a factor of 100. Then during the second sample, the attenuation is removed. The Timing and Control Assembly controls this attenuation ratio with the "low and high sensitivity" signals to the Auto Range Selector. The attenuation ratio between the first and second sample on the 1 volt range is accomplished by selecting 5000 μ mho transconductance for the second sample period. (See Table 4-2.) The second sample period on the 1 volt range is always 1/10 sec.

4-74. Manual.

4-75. Depressing one of the manual pushbuttons on the front panel causes a switch closure to ground. This closure is detected by the Auto Range Selector Assembly (A41) through the DC Enable Assembly (A44). Within the Auto Range Selector, two binaries (A and B binaries) along with the "low sensitivity" signal from the Timing and Control Assembly selects the Input Attenuator and Sensitivity Resistor(s) settings according to Table 4-2 for the first sample period. The Input Attenuator and Sensitivity Resistor(s) settings during the second sample period are controlled by the two binaries and the "high sensitivity" signal.

4-76. Auto.

4-77. When the front panel AUTO pushbutton is depressed, the voltmeter automatically selects the appropriate range. Downranging occurs at 10% of full scale, and upranging occurs at 120% of full scale.

4-78. With the AUTO pushbutton depressed, a switch closure to ground is applied to an amplifier within the Auto Range Selector. The output of the amplifier "auto range select" is applied to the Timing and Control Assembly. The "auto range select" signal within the Timing and Control Assembly generates an "uprange command" during each sample period and a "downrange command" during the second sample period. The "uprange and downrange command" signals are applied back to the Auto Range Selector.

4-79. Downranging.

4-80. If the applied voltage is less than 10% of full scale, the first two digits will be zeroes, and the first and second digit Counting Units will generate a "zero detect" signal. The "zero detect" signal goes through the Polarity Control portion of the Counter Driver Assembly and is applied to the Auto Range Selector as a "downrange enable" signal. The simultaneous occurrence of the "downrange enable" and the "downrange command" from Timing and Control will cause the instrument to downrange, unless the 3460B is on the 1 volt range.

4-81. Upranging.

4-82. If the applied voltage is greater than 120% of full scale, the first two Counting Units produce an "uprange enable" signal. Simultaneous occurrence of the "uprange enable" and the "uprange command" from Timing and Control will cause the instrument to uprange, unless the 3460B is on the 1000 volt range.

4-83. INPUT POLARITY INDICATION.

4-84. During the first sample period, the polarity of the input voltage is sensed by the Polarity Control portion of the Counter Driver Assembly and displayed as part of the front panel display.

4-85. The "zero detect" signals from all the Counting Units enable the polarity indication to change polarity as necessary when all the Counting Units indicate zero counts (zero display).

4-86. COUNT UP-DOWN ENABLING.

4-87. The Counting Units are enabled to count up or down during both the first and second sample periods. During the first sample period, the direction of count may be up or down depending upon the level of superimposed noise and the dc signal being measured.

4-88. During the second sample period (integration interval), the Counting Units count up or down according to the polarity of the V-to-F Converter input voltage and/or superimposed noise. One of four count up or count down conditions will exist during the second sample period as follows:

a. When the input voltage is positive (+ indication on display) and the difference voltage between the input voltage and the D-to-A voltage is positive, the Counting Units count up. The pulses passed by the second sample gate are added to the counts stored in the Counting Units for the first, second, third, and fourth digits through the Counting Units for the last two digits of the display.

b. When input voltage is negative (- indication on display) and the difference voltage between the input voltage and the D-to-A voltage is negative, the Counting Units count up.

c. When the input voltage is positive and the difference voltage between the input voltage and the D-to-A voltage is negative, the Counting Units count down. The pulses passed by the second sample gate are subtracted from the counts stored in the Counting Units for the first, second, third, and fourth digits through the Counting Units for the last two digits of the display.

d. When the input voltage is negative and the difference voltage between the input voltage and the D-to-A voltage is positive, the Counting Units count down.

4-89. The four conditions given in Paragraph 4-88 may also be expressed as follows:

a. When the absolute value of the D-to-A output voltage is smaller than the input voltage, the Counting Units count up.

b. When the absolute value of the D-to-A output voltage is larger than the input voltage, the Counting Units count down.

4-90. With all "zero detect" signals present, zero counts in all Counting Units, the direction of count is always up.

4-91. TIMING AND CONTROL ASSEMBLY.

4-92. The Timing and Control Assembly (A14) performs the programming for each reading period of the Voltmeter. All the components making up the Timing and Control Assembly are mounted on an etched circuit board outside the guard. The assembly is essentially selfsustaining in operation. Figure 4-3 is a simplified operating sequence chart for each reading period. Figure 4-4 illustrates the timing sequence and waveforms of one reading period. Figure 4-5 is a logic block diagram illustrating circuits contained within the assembly. Figure 7-13 is the schematic diagram of the Timing and Control Assembly. See Table 4-1 for definition of logic symbology used in Figure 4-5.

4-93. LOGIC TERMINOLOGY.

4-94. The circuits contained within the Timing and Control Assembly are discussed using logic terminology letters such as "E" with the complementary or reverse condition of E indicated by the placement of an overscore above E "$\overline{E}$," read as "E bar" or "not E." The logic terminology letters, names, and logic levels, are given in Table 4-3. Also, contained in the table, is the name and logic levels of the D flip-flop located outside the Timing and Control Assembly. The logic terminology letters given in Figures 4-3 and 4-4 indicate the true state of the flip-flop or one-shot. The signal flow arrows (••••►) on Figure 4-4 indicate the sequence of operation; for example, when C true goes $\overline{C}$ true at the beginning of a reading period, it permits T true to change to $\overline{T}$ true after the time delay of τ_2.

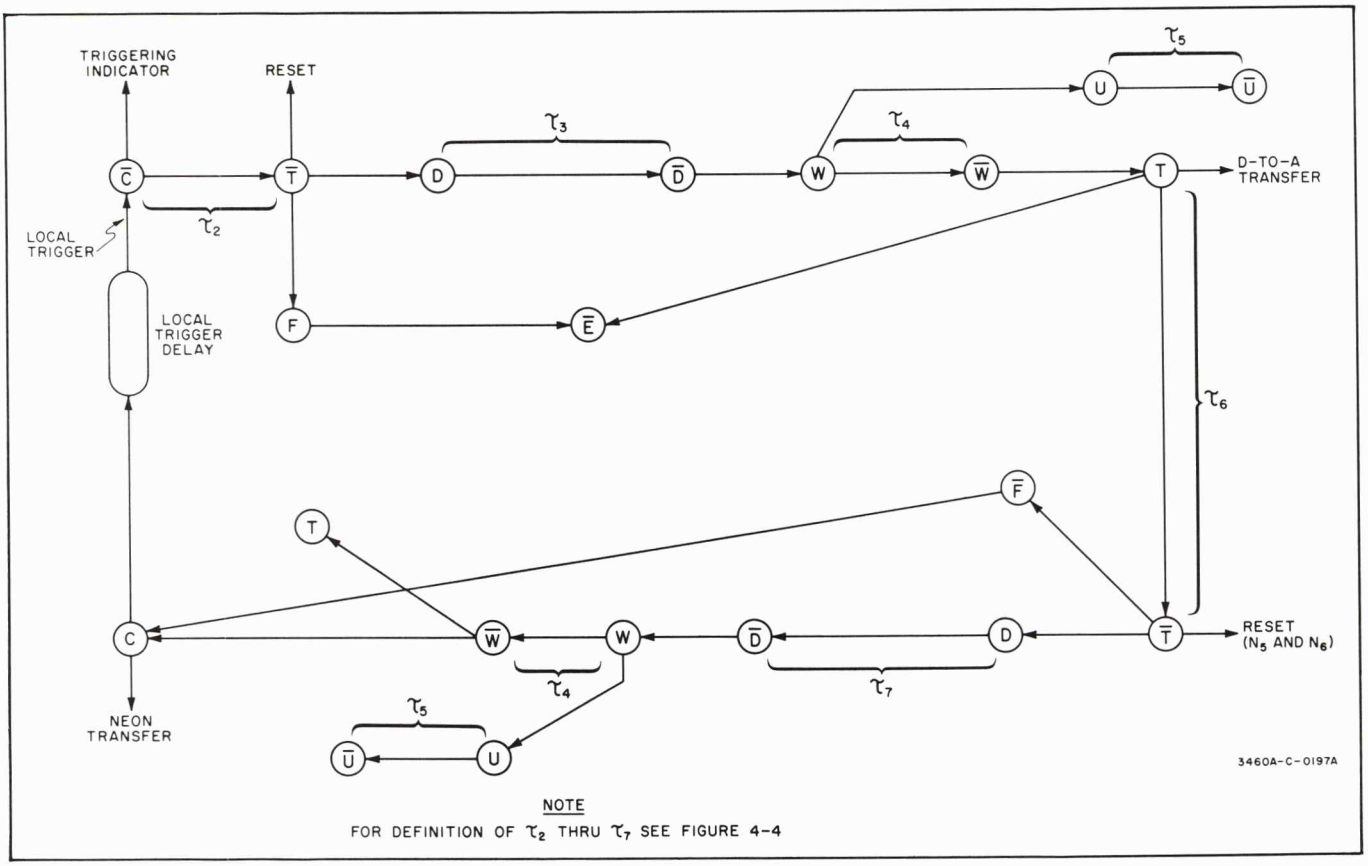


Figure 4-3. Simplified Sequence Chart

4-95. SEQUENCE OF OPERATION.

4-96. In the LOCAL mode of operation, each reading period is initiated by a local trigger generated within the assembly in conjunction with the TRIGGERING RATE control (R1) and local trigger delay generator (Q15). The time required to develop the local trigger is determined by the setting of the front panel RATE control. The negative true local trigger is developed at the input to the reading period flip-flop (C) and sets $\overline{C}$ true when inverter amplifier Q23 is turned on. Inverter amplifier Q23 is turned on with a positive going ramp developed by the local trigger delay generator and the time delay network C4, A20R6 and the RATE control. The time delay network is active only when the output of Q15 is positive (Q15 conducting); therefore, the RATE control determines the delay between reading periods, not the duration of a reading period. This delay (0.13 to 5 sec) is referred to as the display period in Figure 4-4. When the local trigger sets $\overline{C}$ true, Time T_0 is initiated as indicated in Figure 4-4 and a reading period is started. The setting of the C flip-flop to C true at time T_0 removes the positive signal (C false) holding the D/A Transfer one-shot (T) in the T true state through the inverter amplifiers Q13, Q15 and the OR Gate CR21. With the output of Q15 going negative at time T_0, the time delay network becomes inactive and the local trigger is terminated. With the absence of the positive signals ($\overline{C}$ false and $\overline{Z}$ false) from the OR Gates CR21 and CR35, the T one-shot is enabled to return to the stable state ($\overline{T}$ true) after a short time delay of approximately 1 ms. The logic level of the C waveform is inverted in Figure 4-5 because of the location of TP1 and the Inverter Amplifier Q13.

4-97. D-to-A Control Lines.

4-98. The T one-shot returns to its stable state at time T_1, the $\overline{T}$ true signal off the collector of Q9 is out of phase with the T waveform given in Figure 4-4 because of the location of TP3 where the T waveform is observed. The $\overline{T}$ true signal is applied through the emitter follower Q10 and becomes the "D/A reset enable/storage" signal. The signal is also applied through an additional amplifier and emitter follower, Q11 and Q12, to become "D/A Transfer/reset" signal. An E true signal (low sensitivity) from sensitivity flip-flop (E) is also applied to input of amplifiers Q11 and Q12. The various states of T one-shot and E flip-flop controls the three conditions (reset, transfer and storage) of the storage binaries circuits contained in the first four Counting Units by applying various voltage levels to the "D/A reset enable/storage" and "D/A transfer/reset" lines. Refer to the discussion of Counting Units for voltage levels required for the three conditions of the storage binaries. With $\overline{T}$ and E true, the "D/A reset enable/storage" line is relatively negative (approximately -28 volts) and the "D/A transfer/reset" line is relatively positive (approximately 0 volts), establishing a "Storage Condition" for the storage binaries and enabling the counting binaries to count the pulses generated during the first sample period.

4-99. A42 or A39 Sample Delay, DC Enable Assembly.

4-100. A42 contains the Sample Delay circuit in addition to the DC Enable Circuits normally located on the 3460B A44 Assembly. A42 is used only in Option 004 and 005 instruments. In Option 006 and 007 instruments, the Sample Delay circuit is located on the A39 assembly.

4-101. The Sample Delay circuit provides a 350 msec delay between the beginning of the D-to-A storage period ($\overline{T}$) and the beginning of the Sample Period (D). The 350 msec delay allows the RC filter (part of A50) to respond to the dc input before the sample period begins.

4-102. At the Sample Delay circuit input, T goes from O V to -35 V during the D-to-A storage period and A42Q1 conducts. The collector of A42Q1 is connected through A42 pin 3 to the Filter Enable Circuit on A47 and provides a conduction path (Filter Enable) for A47Q1and A47Q2 during the time T is negative. The Filter Out Program Line, A42; J16 (R) disables A42Q1 and the other filter logic circuits whenever J27 (24) at the 3460B rear panel REMOTE CONTROL connector is connected to circuit ground. When A42Q1 conducts, the one-shot multivibrator A42Q3 and A42Q4 is triggered. The one-shot remains in its unstable state for 350 msec. During the unstable state, A42Q3 is turned off. The collector of A42Q3 is connected through A4CR9 to the Sample Delay Switch, A47Q4. The Sample Delay Switch holds off the Sample Period Flip-Flop (p/o A17) during the 350 msec delay. At the end of the delay, A42Q3 conducts and turns on A47Q4 which triggers the Sample Period Flip-Flop on A17 and the sample period begins.

4-103. A42 replaces the 3460B A44 assembly in the Option 004 and 005 instruments.

4-104. First Sample Period.

4-105. The $\overline{T}$ signal at time T_1 is also applied to amplifier Q3 through an AND Gate (CR6, CR7 and CR5) and a time delay (C8) to generate a "sample enable" signal. The time delay network enables the counting binaries in the proper Counting Units to be reset before the initiation of a sample period. The Counting Units are reset with a positive true "counter reset initiate" signal (T false) at time T_1. The other two inputs to the AND Gate (CR6, CR7, and CR5) verifies the proper state of the W one-shot and the sample period flip-flop (D) on the A17 Assembly before the initiation of a sample period. The positive true "sample enable" signal from Q3, as discussed in the Detailed Block Diagram theory, sets D true at time T_1, initiating the first sample period. In addition to setting D true at Time T_1, a T false (positive) signal is applied to the sample period flip-flop (F) and sets F true indicating first sample period in process.

4-106. The period of time that D remains true (T_1 to T_2) is the first sample period of one reading. At the end of the first sample period, time T_2, a D false signal, "end of sample period" from the Sample Period Generator, is applied to the auto ranging one-shot (W) and sets W true, the unstable state of the W one-shot. The W waveform shown in Figure 4-4 is observed at TP2. The W one-shot returning to stable state ($\overline{W}$ true) after 0.5 ms sets the T one-shot to the T true state with a W false signal at time T_3, and initiates "auto range command" for automatic ranging as discussed in Detailed Block Diagram theory.

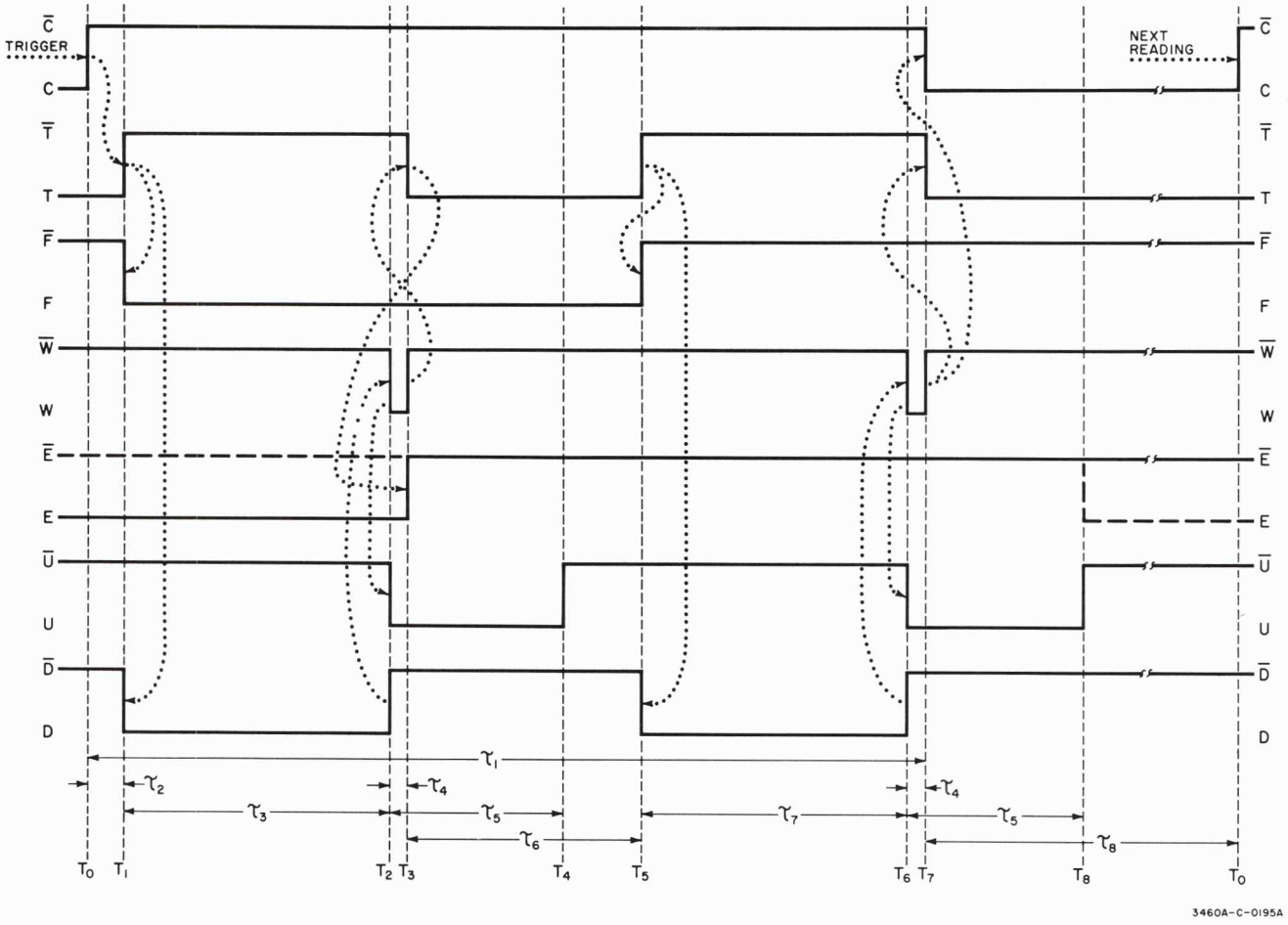
4-107. D-to-A Transfer.

4-108. At time T_3, a T true signal is applied to an AND Gate (CR25 and CR26). The other input to the AND Gate is received from the F flip-flop (F true) and the output of the gate sets $\overline{E}$ true (Q19 cutoff) on the E flip-flop. The "D/A reset enable/storage" and "D/A transfer/reset" signal levels selected by T true and $\overline{E}$ true enables a "Transfer Condition" and all the counts contained in the Counting Units are stored in the storage binaries and equivalent counts transfer to the D-to-A Converter. The negative "D/A transfer/reset" signal at time T_3 also enables polarity of the input voltage to be transferred to the D-to-A Converter as discussed in Counter Driver theory. The period of T true (Q3 cutoff) is approximately 15 ms and is referred to as the D/A transfer period.

4-109. At time T_2, just prior to D/A transfer period, the change in the W one-shot sets the maximum count rate inhibit one-shot (U) to the U true state with a $\overline{W}$ false signal. During the period of U true (7 ms), a "low sensitivity" signal caused by "maximum count rate detection" as discussed in the Detailed Block Diagram theory is prohibited. The reason for count rate inhibit is to permit completion of D/A transfer operation.

4-110. Second Sample Period.

4-111. When the T one-shot returns to stable state at time T_5, a T false signal returns the F flip-flop to $\overline{F}$ true state. The $\overline{T}$ true state signal at time T_5 again generates a "sample enable" signal through amplifier Q3 for the second sample period. The second sample period (D true) is in process from time T_5 to T_6 as illustrated in Figure 4-4. At the end of the second sample period, a D false signal, "end of sample period," from the Sample Period Generator Assembly repeats the functions performed after the first sample period by setting W true. The W one-shot again sets T and U true at time T_6 and T_7. At time T_7 a W false signal is supplied to two AND Gates in the reading termination gate matrix where along with $\overline{F}$ true (CR47) signal and a "not overload" signal (CR45) sets the C flip-flop to C true state through OR Gate (CR40). Setting C true at time T_7 terminates the reading period.



τ_1 = One reading period

τ_2 = Delay in T flip-flop after C set true (1 ms)

τ_3 = First sample period (1/60 or 1/10 sec)

τ_4 = Unstable period of the auto ranging one-shot (W) (0.5 ms)

τ_5 = Unstable period of the max count rate inhibit one-shot (U) (7 ms)

τ_6 = D/A transfer period (15 ms)

τ_7 = Second sample period (1/60 or 1/10 sec)

τ_8 = Display period of 130 ms to 5 sec (in LOCAL mode of operation)

T_0 = Start reading period

T_1 = Reset Counting Units and start first sample period

T_2 = End of first sample period

T_3 = Start D/A transfer

T_4 = End of max count rate inhibit after first sample period

T_5 = Reset 5th and 6th digit Counting Units and start second sample period

T_6 = End of second sample period

T_7 = Neon transfer and end of reading period

T_8 = End of max count rate inhibit after second sample period

Figure 4-4. Timing and Control Waveforms

Table 4-3. Logic Terminology

LETTER	NAME	LOGIC LEVEL	FUNCTION
C	Reading period Flip-flop	C True = Negative signal from C side (Q2 cutoff) C False = Positive signal from C side (Q2 conducting) $\overline{C}$ True = Negative signal from $\overline{C}$ side (Q1 cutoff) $\overline{C}$ False = Positive signal from $\overline{C}$ side (Q1 conducting)	Indicates the initiation of reading period by local or remote trigger and the duration of a reading period. $\overline{C}$ true = reading period in process
D	Sample Period Flip-flop (A17)	D True=Negative signal from D side (Q2 cutoff) D False = Positive signal from D side (Q2 conducting) $\overline{D}$ True = Negative signal from $\overline{D}$ side (Q1 cutoff) $\overline{D}$ False = Positive signal from $\overline{D}$ side (Q1 conducting)	Permits pulses from V-to-F Converter to be counted. D true - sample period in process
E	Sensitivity	E True = Negative signal from E side (Q18 cutoff) E False = Positive signal from E side (Q18 conducting) $\overline{E}$ True = Negative signal from $\overline{E}$ side (Q19 cutoff) $\overline{E}$ False = Positive signal from $\overline{E}$ side (Q19 conducting)	Determines the sensitivity of V-to-F Converter for first and second sample periods. E true = low sensitivity $\overline{E}$ true = high sensitivity
F	Sample counter Flip-flop	F True = Negative signal from F side (Q17 cutoff) F False = Positive signal from F side (Q17 conducting) $\overline{F}$ True = Negative signal from $\overline{F}$ side (Q16 cutoff) $\overline{F}$ False = Positive signal from $\overline{F}$ side (Q16 conducting)	Keeps track of sample periods. F true = first sample period $\overline{F}$ true = second sample period
T	D/A Transfer One-shot ($\overline{T}$ true stable state)	T True = Negative signal from T side (Q8 cutoff) T False = Positive signal from T side (Q8 conducting) $\overline{T}$ True = Negative signal from $\overline{T}$ side (Q9 cutoff) $\overline{T}$ False = Positive signal from $\overline{T}$ side (Q9 conducting)	Establishes the time of D/A transfer between sample periods. T true = D/A transfer period.
U	Max Count Rate Inhibit one-shot ($\overline{U}$ true stable state)	U True = Negative signal from U side (Q6 cutoff) U False = Positive signal from U side (Q6 conducting) $\overline{U}$ True = Negative signal from $\overline{U}$ side (Q7 cutoff) $\overline{U}$ False = Positive signal from $\overline{U}$ side (Q7 conducting)	Inhibit "max count rate detection" during a D/A transfer period. U true = max count rate inhibit
W	Auto Ranging One-shot ($\overline{W}$ true stable state)	W True = Negative signal from W side (Q4 cutoff) W False = Positive signal from W side (Q4 conducting) $\overline{W}$ True = Negative signal from $\overline{W}$ side (Q5 cutoff) $\overline{W}$ False = Positive signal from $\overline{W}$ side (Q5 conducting)	Causes automatic ranging, and termination of reading period after second sample period. Change in W going from true to false equal "auto range command."
Z	Max Count Rate One-Shot ($\overline{Z}$ true stable state)	Z True = Negative signal from Z side (Q20 cutoff) Z False = Positive signal from Z side (Q20 conducting) $\overline{Z}$ True = Negative signal from $\overline{Z}$ side (Z21 cutoff) $\overline{Z}$ False = Positive signal from $\overline{Z}$ side (Q21 conducting)	Permits the D-to-A reed relays to stabilize after a "max count rate detection" signal resets the D-to-A Converter. $\overline{Z}$ false holds the T one-shot in the T true stage

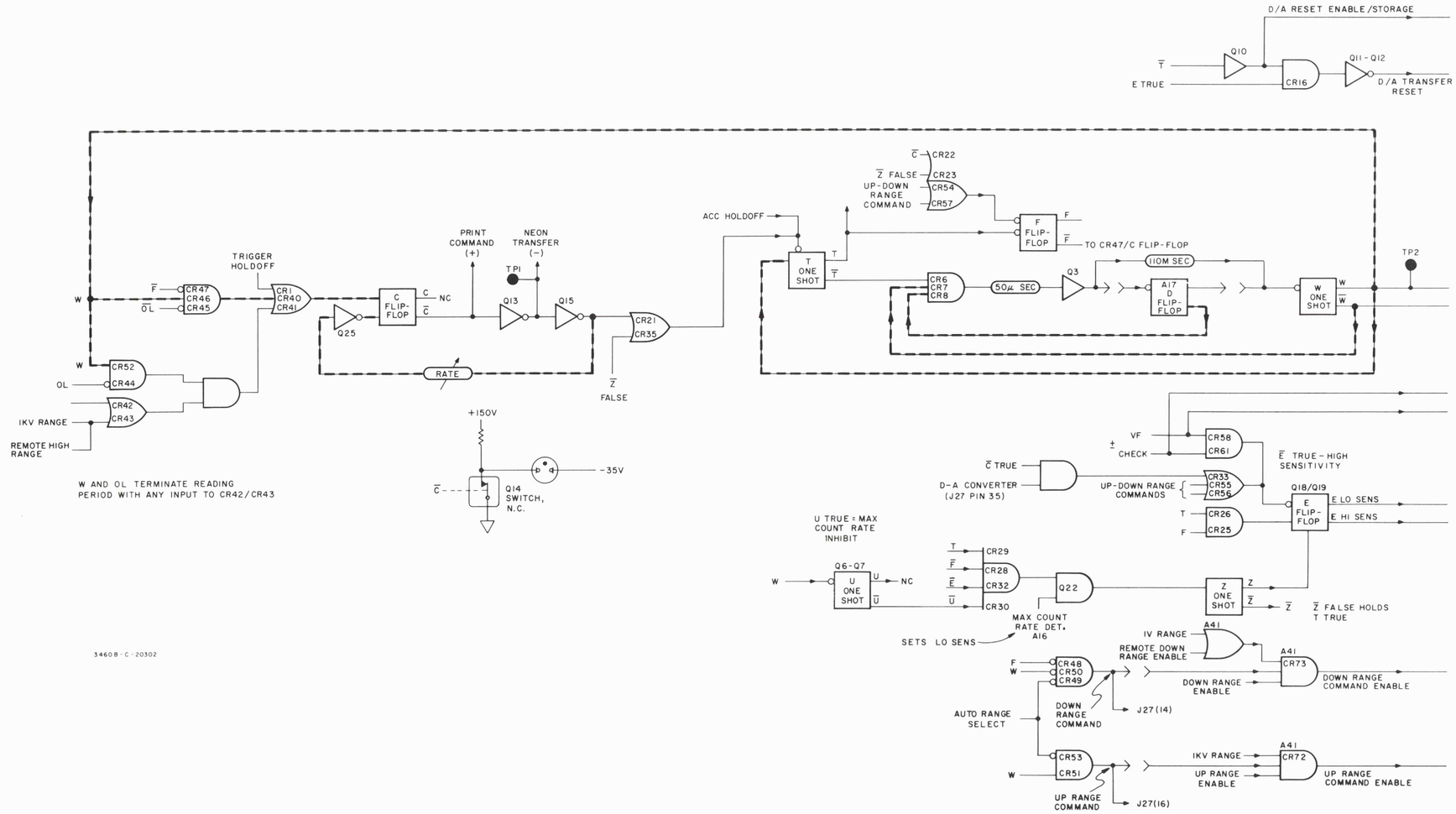


Figure 4-5. Timing and Control Logic Diagram

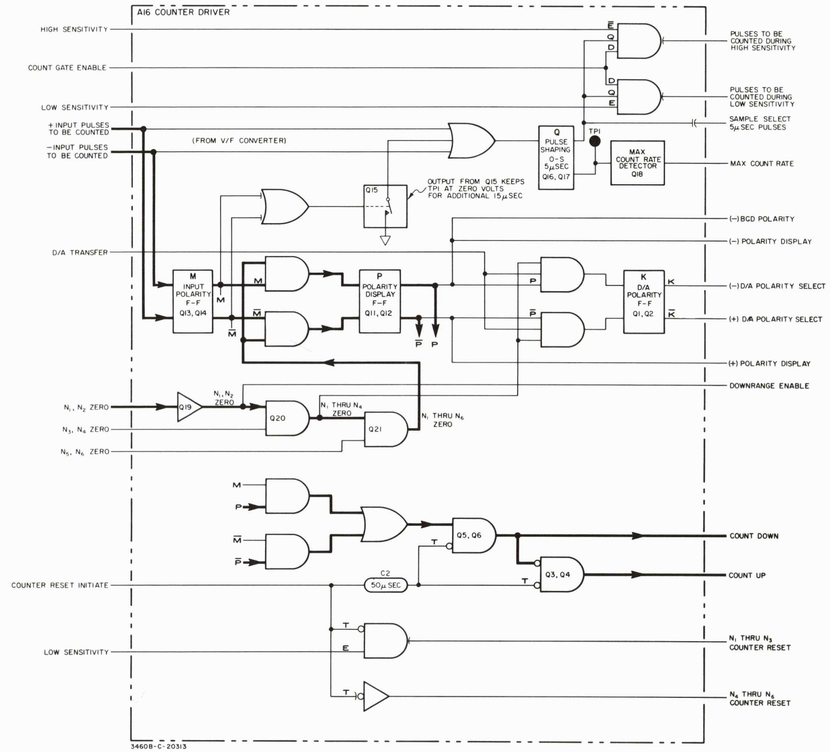


Figure 4-6. Counter Driver Assy. Logic Diagram

4-112. The reading period may also be terminated by setting C true with automatic ranging and overload signals as shown in Figure 4-5. With an overload condition during a manual range setting, the reading period is terminated through CR41 with a false "auto range select" signal (0 volts) applied to CR42, a true "overload" signal (relatively negative) and a W false signal. During automatic ranging with overload condition on the 1000 volt range, the reading period is terminated through CR41 with a true "1000 volt range" signal (0 volts), a true "overload" signal and a W false signal. The "trigger holdoff" signal applied through CR1 is used to hold off the initiation of a new reading period when using the 3460B with a digital recorder or remotely programming the reading period.

4-113. Display Period.

4-114. The C flip-flop in the C true state generates a $\overline{C}$ false signal making the "print command" signal go positive (-17 to 0 volts) and the "neon transfer" signal through the inverter amplifier Q13 go negative (0 to -35 volts). A negative "neon transfer" signal enables all the counts contained in the Counting Units to be transferred to the front panel digital display. The $\overline{C}$ false signal is also applied to the F flip-flop through CR22 to assure an $\overline{F}$ true state for the next reading period. The time from T_7 to the beginning of the next reading period (T_0) is the display period. The display period is adjustable by the front panel TRIGGERING RATE control from approximately 0.13 to 5 sec in LOCAL mode of operation. With the TRIGGERING RATE in the HOLD position, the display period remains true until the triggering pushbutton is depressed or until a new reading period is initiated by a remote trigger during a REMOTE mode of operation. The front panel digital display remains unchanged after completion of the display period until the next "neon transfer" command is received. The display period plus the reading period gives the total time between initiations of reading periods. With the front panel RATE control full clockwise and a constant input voltage, a typical time between initiations of reading periods equals $\simeq$ 346 ms in the LOCAL mode of operation. The minimum time between initiations of readings (max reading rate) is $\simeq$ 66 ms in the REMOTE mode of operation.

4-115. SENSITIVITY FLIP-FLOP.

4-116. Setting E true (low sensitivity) for first sample period is controlled by the $\overline{C}$ true signal from the C flip-flop if the "program D/A converter reset" line is grounded, or a Z true signal from the maximum count rate one-shot (Z) as shown in Figure 4-5. The "program D/A converter reset" line is pin 35 on REMOTE CONTROL connector. Grounding pin 35 resets the D-to-A Converter at the end of each reading period.

4-117. The setting of max count rate one-shot to the Z true state (unstable state) is initiated by a negative true "max count rate detection" signal from the Counter Driver Assembly (A16) control by the two AND Gates as shown in Figure 4-5. When the Z one-shot is set to Z true, a $\overline{Z}$ false signal off the $\overline{Z}$ side of the one-shot is applied to T one-shot through OR Gate (CR35) to hold the T one-shot in the true state during the duration of Z one-shot (15 ms). The Z one-shot may be set to Z true state only between time T_0 and T_1 or between time T_8 and the setting of $\overline{T}$ true for the next reading period.

4-118. When the Z one-shot is set to Z true by "max count rate detection," a "low sensitivity" signal is programmed as discussed in Paragraph 4-57 resulting in a 1/60 sec first sample period. If both pins 18 and 35 on the REMOTE CONTROL connector are open and a "max count rate detection" signal fails to come in, the sensitivity flip-flop remains in the $\overline{E}$ true state (high sensitivity) for both the first and second sample periods. With "high sensitivity" true, the period of D true (sample period) is 1/10 sec for both the first and second sample periods as discussed in Paragraph 4-58.

4-119. The E flip-flop is also set to the E true state through OR Gate CR55 and CR56. When an uprange or downrange command is generated simultaneously with "uprange enable" or "downrange enable" signals respectively, as discussed in Detailed Block Diagram theory, E is set true.

4-120. D-to-A Reset.

4-121. With T and E set true during the time from T_8 to the setting of $\overline{T}$ true for the next reading period, a "reset Condition" is established for storage binaries within the Counting Units. The "Reset Condition" resets all storage binaries and the D-to-A Converter to zero. The E true signal at the input to amplifiers Q11 and Q12 overrides the $\overline{T}$ false signal to make the D/A transfer/reset line relatively positive (0 volts) during a "Reset Condition."

4-122. Sample Bypass.

4-123. The 110 ms delay between "sample enable" and "end of sample period" signals is used as a bypass to continue the reading period if there are no pulses (null) from the V-to-F Converter. The 110 ms time delay will set W true after 110 ms. The start of the second sample period is synchronized to pulses out of the V-to-F Converter. Refer to discussion on Sample Period Generator for additional information.

4-124. SAMPLE PERIOD GENERATOR ASSEMBLY.

4-125. The Sample Period Generator Assembly (A17) is physically located outside the guard as shown in Figure 7-1. The schematic diagram for the A17 assembly is given in Figure 7-15. A simplified diagram of the Sample Period Generator Assembly is given in Figure 4-7. The selection of the 1/60 sec or 1/10 sec sample period, "Gate inhibits" on pins 4, 13, and 14, and the "sample start-stop inhibit" on pin 7 are not shown in Figure 4-7.

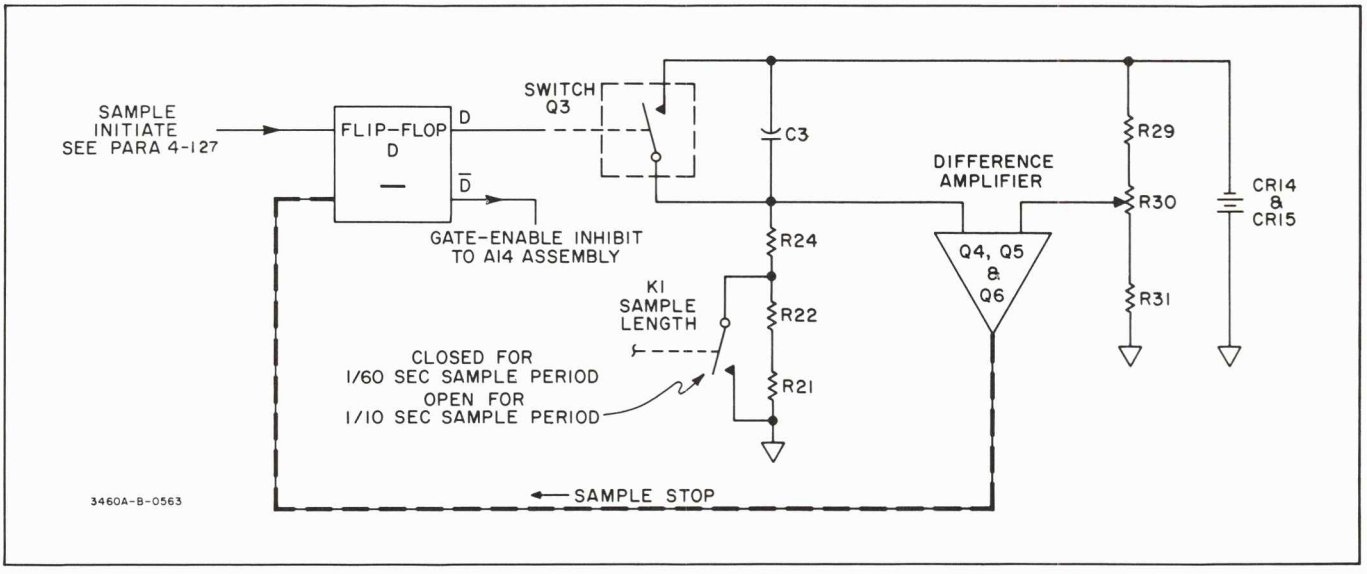


Figure 4-7. Simplified Sample Period Generator

4-126. The Sample Period Generator contains the sample period flip-flop (D) discussed in paragraphs describing the Timing and Control Assembly, an AND Gate Q7, switch Q3, difference amplifiers Q4, Q5 and Q6 and associated control circuits.

4-127. SAMPLE INITIATE.

4-128. The sample period is initiated through diodes CR1 or CR4. The state of the sample period flip-flop during a sample period is D true (negative true logic), transistor Q2 cutoff.

4-129. 1/60 Second Sample Period Select.

4-130. Transistor Q7 is biased on by the voltage divider network R9, R8, and R4 when the "sample enable" line (pin 8) is false (approximately -17 volts) and the "1/60 sec sample select" signal is absent. To generate a 1/60 second sample period, as discussed in the Detailed Block Diagram theory, both the "1/60 sec sample select" and "sample enable" signals must be true (relatively positive).

4-131. The "1/60 sec sample select" signal is positive true and generated by the Auto Range Selector Assembly (A41) when a "low sensitivity" (E) signal is received from the Timing and Control Assembly or when the 1/60 sec sample period is remotely programmed and the 3460B is not on the 1 volt range. The "sample enable" signal is also positive true from the Timing and Control Assembly. The "sample enable" signal is true when transistor A14Q3 is cut off by the D/A Transfer one-shot (T) at time T_1 and T_5 as illustrated in Figure 4-4. With "1/60 sec sample select" true, the coil L1 on the Sample Period Generator Assembly is energized and the "sample length" contact K1 is closed.

4-132. With the "1/60 sec sample select" signal true, transistor Q7 is driven into cutoff when a true "sample enable signal" is applied to the base. With Q7 cut off and no pulse present through CR10, a negative signal is applied to the base of Q1 through diode CR1 setting the D flip-flop to the D true state (transistor Q1 conducting). When Q1 is driven into conduction, a D true signal "count gate enable" from the collector of Q2 is applied to the Counter Driver Assembly (A16) and the base of Q3 through R18 and R19.

NOTE

The "count gate enable" signal at pin 5 is a D true signal to the Counter Driver Assembly, and the "end of sample period" signal at pin 5 is a D false signal to the Timing and Control Assembly.

4-133. A D true signal drives Q3 into cutoff opening the switch illustrated in Figure 4-7. With the switch open, the total voltage developed across breakdown diodes CR14 and CR15 is applied across C3 and R24 through K1. Capacitor C3 charges up through R24 until Q4A, part of difference amplifier shown in Figure 4-7, starts to conduct at a voltage level determined by the difference amplifier reference level resistors R29, R30 and R31.

4-134. The time it takes C3 to reach a charge sufficient to cause Q4A to conduct is equal to one sample period (1/60 sec with the "sample length" contact closed). When transistor Q4A conducts, transistor Q4B is biased to cutoff through the emitter circuit, and Q5 is cut off by the negative potential at the collector of Q4A. With Q4B cut off, the bias developed by the voltage divider network R28 and R32 drives Q6 into conduction. With Q6 conducting, a negative level "sample stop" is fed back through CR7 to the D flip-flop to set $\overline{D}$ true (Q2 conducting). When the D flip-flop returns to the $\overline{D}$ true state, a D false (positive)

signal, "end of sample period," is sent to the Timing and Control Assembly to indicate an end of sample period. In addition to the "end of sample period" signal, when the D flip-flop returns to the $\overline{D}$ true state, the switch illustrated in Figure 4-7 closes (Q3 cuts off) discharging capacitor C3. With the switch closed, the transistors in the difference amplifier return to original conditions Q4A and Q6 cutoff with Q4B and Q5 conducting.

4-135. 1/10 Sec Sample Period Select.

4-136. The 1/10 sec sample period, as discussed in the Detailed Block Diagram theory, is generated by the following signals:

a. A "sample enable" signal from the Timing and Control Assembly.

b. A "1/10 sec sample select" signal from the Counter Driver Assembly.

c. The absence of "1/60 sec sample select" signal from the Auto Selector Assembly.

4-137. Both the "sample enable" and "1/10 sec sample select" signals are positive true. The "sample enable" signal is discussed in Paragraph 4-131. The "1/10 sec sample select" signal from the Counter Driver Assembly synchronizes the initiation of the second sample period with a pulse from the V-to-F Converter. The absence of "1/60 sec sample select" signal from the A41 assembly holds coil L1 de-energized and the "sample length" contact K1 open. A true "sample enable" signal removes the negative clamp applied to pin 6 (1/10 sec sample select) through diode CR5. With the clamp removed, a true "1/10 sec sample select" signal drives Q2 into cutoff through diode CR4 setting the D flip-flop to the D true state.

4-138. The operation of the sample period generator for 1/10 sec sample period with the D flip-flop set to the D true state is the same as described for the 1/60 sec sample period with the exception that the charging of capacitor C3 is through a longer time constant of R24, R22, and R21.

4-139. Sample Period Control.

4-140. The "sample stop inhibit" signal through CR11 inhibits "sample stop" during a pulse from the V-to-F Converter. The "sample stop inhibit" signal also inhibits the starting of a 1/60 sec sample period through diode CR10 during a pulse from the V-to-F Converter. The "gate enable inhibit" signal (pin 15) to the Timing and Control Assembly prohibits the "sample enable" signal being generated during a sample period. Refer to discussion of Timing and Control Assembly.

4-141. COUNTER DRIVER ASSEMBLY.

4-142. The Counter Driver Assembly (A16) directs the pulses generated by the V/F Converter to the proper Counting Units, controls front panel polarity display, controls polarity of the D/A Converter output voltage, determines the direction of count within the Counting Units, and resets the Counting Units.

4-143. A logic diagram of the polarity control, count up-down enabling, and the max count rate detection portions of the Counter Driver Assembly is illustrated in Figure 4-6. The heavy lines in Figure 4-6 indicate the main signal flow in generating a count-up or count-down enabling signal. Additional logic for the Counter Driver Assembly including counter reset, is illustrated on the Detailed Block Diagram, Figure 7-2.

4-144. UP-DOWN COUNT ENABLING.

4-145. With a positive voltage applied to the input binding posts, the V/F Converter generates positive pulses out of the positive Pulse Transformer (T2) during the first sample period. The pulses out of the positive pulse transformer are applied to the input polarity flip-flop M through CR22 setting M true.

4-146. A "zero detect" signal (-30 volts) is generated by each Counting Unit in the zero display state (zero counts). The "zero detect" signals from all the Counting Units (N_1 through N_6) are applied to the Counter Driver Assembly as shown in the upper left hand corner of the logic diagram. With all "zero detect" signals present and the M flip-flop in the M true state, the AND Gate R55 and CR18 is enabled. The output of the AND Gate sets the polarity indicator flip-flop P to P true state. With the flip-flop in the P true state, a $\overline{P}$ false signal (approximately 0 volts) is applied to the Auto Range Selector Assembly (A41) for (+) polarity indication on the front panel display.

4-147. The P true signal from the P flip-flop is applied to the AND Gate CR6 and CR7. A signal from the M flip flop (M True) is also applied to the same AND Gate enabling the output. The output of the AND Gate is applied to amplifier Q5 and Q6 through an up-down disable OR Gate. Amplifier Q5 and Q6 inverts the negative output from AND Gate CR7 and CR6 to a positive level disabling the count-down lines to all Counting Units. With the output of amplifier Q5 and Q6 positive and the "up-down disable" line positive (50 μ sec after $\overline{T}$ true), the output of the OR Gate R17 and R15 is positive. The positive output from OR Gate R17 and R15 is inverted by amplifier Q3 and Q4 to a negative 30 volts enabling the count-up lines to all Counting Units.

4-148. The direction of count with all Counting Units set to zero is always up independent of the input voltage polarity. The condition discussed above is with a positive input voltage applied to the voltmeter. With a negative input voltage applied, the AND Gate R56 and CR19 is enabled by $\overline{M}$ true and "zero detect" signals from all Counting Units and a $\overline{P}$ true signal is applied through AND Gate CR4 and CR5. The $\overline{P}$ true signal enables the count-up lines on all Counting Units through the two inverter amplifier and OR Gates in the same manner as the P true signal previously discussed. The count-down lines are enabled with absence of a negative output signal from both AND Gates (CR7, CR6, and CR4, CR5) and a positive "up-down disable" signal producing a negative level at output of amplifier Q5 and Q6. With the P flip-flop in the $\overline{P}$ true state, a P false signal is applied to the auto Range Selector Assembly (A41) for (-) polarity indication.

4-149. The Counter Driver Assembly functions in the following manner when a count-down condition, as described in the Detailed Block Diagram theory, exists. With a positive input voltage, the count-up lines are enabled as described above during the first sample period. If, during the second sample period, the difference voltage is negative, the M flip-flop will change state; but the P flip-flop will remain in the P true state, disabling both AND Gates (CR7, CR6 and CR4, CR5). With the AND Gates disabled and a positive "up-down disable" signal, the count-down lines are enabled through OR Gate R18 and amplifier Q5 and Q6.

4-150. The four conditions of count-up or down during the second sample period are determined by polarity of the D-to-A Converter voltage and the polarity of the difference voltage between the input voltage and the D-to-A voltage is discussed in the Detailed Block Diagram. The four conditions of count-up or down, as illustrated in Figure 4-8, will result in setting the M and P flip-flops to the true states indicated in the figure.

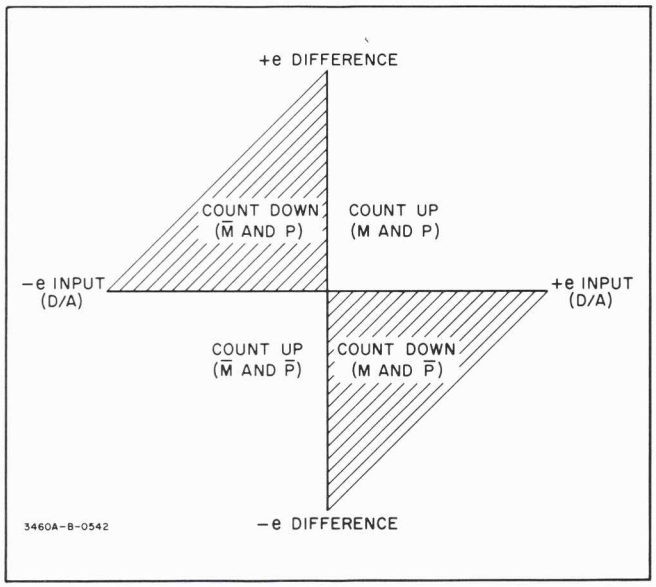


Figure 4-8. Count Up-Down Enabling

4-151. UP-DOWN DISABLE.

4-152. The "up-down disable" signal prohibits count-up and count-down enabling during a counter reset by holding the "up-down disable" line at a negative level for 50 μ sec after a positive true "counter reset initiate" signal is received. The "up-down disable" signal also prohibits count-up and count-down enabling during a D/A Transfer period (T true). Any time the "up-down disable" line is at a negative level, both the count-up and count-down lines are disabled through the two OR Gates and inverter amplifiers.

4-153. D-TO-A CONVERTER POLARITY CONTROL.

4-154. With a positive input voltage applied during first sample period, the $\overline{P}$ false signal is also applied to AND Gate R95 and R91 as illustrated in the logic diagram. The remaining input (R91) to the AND Gate is the negative true "polarity relay inhibit" signal from the Q20 Amplifier. The output of Q20 is negative with N_1, N_2,N_3 and N_4 "zero detect" signal present. Therefore, a true "polarity relay inhibit" signal prohibits a D/A polarity selection until there are counts in any one of the first four Counting Units.

4-155. With the AND Gate R95 and R91 enabled, the output of Q10 goes negative and is applied to the polarity relay flip-flop (K) to set $\overline{K}$ true through an AND Gate controlled by "D/A Transfer/Reset" signal. The $\overline{K}$ true signal energizes K13 on the D-to-A Relay Assembly (A21). With A21K13 energized, the output of the D-to-A Converter is positive. The "polarity relay inhibit" signal prevents switching of polarity relays K13 and K14 on the A21 Assembly when the Model 3460B has only zeroes in the first four digits. A negative true "D/A Transfer/Reset" is applied to Counter Driver Assembly during a D/A transfer period (T_3 to T_5).

4-156. With a negative input voltage during the first sample period, a negative D-to-A Converter Voltage is selected by setting the K flip-flop to the K true state through amplifier Q9.

4-157. CROSS-OVER DELAY.

4-158. Both outputs from the M flip-flop are also applied to the switch Q15 through capacitively coupled OR Gate C14 and C13. The output from the OR Gate biases Q15 "on" (closed) for approximately 15 μ sec each time the M flip-flop changes states. With switch Q15 closed, the multivibrator Q16 and Q17 is held "on" approximately 20 μ sec enabling the Counting Units to switch from count-up to count-down or vice- versa before the next pulse is received from the pulse shaping multivibrator. The cross-over delay described above is operative only when the M flip-flop changes state.

4-159. SAMPLE PERIOD CONTROL.

4-160. The Counter Driver Assembly generates three signals that are used to control the sample period time.

4-161. 1/10 Sec Sample Select.

4-162. The "1/10 sec sample select" signal from the pulse shaping multivibrator Q16 and Q17 to the Sample Period Generator synchronizes the opening of the second sample gate with a pulse out of the V-F Converter. Refer to the discussion of the Sample Period Generator Assembly for additional information. The "1/10 sec sample select" signal is capacitively coupled to the Sample Period Generator Assembly.

4-163. Sample Stop Inhibit.

4-164. The "sample stop inhibit" signal from the pulse shaping multivibrator to the A17 Assembly inhibits the first and second sample gates from closing during a pulse from the V-to-F Converter.

4-165. Max Count Rate Detection.

4-166. The "max count rate detection" signal as discussed in the Detailed Block Diagram is used to generate a "low sensitivity" signal in the Timing and Control Assembly. The Counter Driver Assembly (refer to schematic diagram) generates the "max count rate" signal as described in the following paragraph.

4-167. As the frequency of the V-to-F Converter reaches 55 kHz, the Junction of R87 and R88, R89 becomes relatively positive (approximately 0 volts) with less current flow through R87. With 0 volts at the Junction of R87 and R88, R89, transistor Q18 is biased "off." When Q18 is cutoff, a negative true "max count rate detection" signal is generated. The RC filter network C17, R90 and C18 filters out the pulses from the pulse shaper; and R88 (THRESHOLD ADJ) determines the frequency at which a "max count rate detection" signal is generated.

4-168. During the 1/10 sec second sample period, a "max count rate detection" signal is generated with $\simeq$ 5% of full scale change in the input voltage between reading periods. With the 1/60 sec second sample period programmed, a "max count rate detection" signal is generated with $\simeq$ 1% of full scale change in the input voltage between reading periods.

4-169. COUNTING UNITS.

4-170. The 3460B Digital Voltmeter utilizes five Reversible Counting Decades (RCD) to aid integration about zero or "nulls." Each Reversible Counting Decade for simplicity of discussion and consistency is referred to as a Counting Unit. The first digit Counting Unit is a single binary circuit (A^1 binary) on the N_1 and N_2 RCD/D-to-A Coil Drive Assembly (A35) (A13 with some optional instruments). Its corresponding display tube is physically located on the Auto Range Selector Assembly (A41). The first digit provides the overrange capability by displaying a "1" between full-scale and up to 20% over full-scale readings. Otherwise, the first digit remains blank. The second, third, fourth, fifth and sixth digit Counting Units consist of four counting binaries per Counting Unit connected in cascade on the A31, A32, A33, A34, and A35 Assemblies (A9, A10, A11, A12 and A13 with some optional instruments). The sixth and fifth digit Counting Units are electrically identical requiring only one schematic and may be interchanged physically within the instrument. The fourth and third digit Counting Units, having a separate storage binary for each counting binary, are also electrically identical as illustrated on the schematic. The fourth and third digit Counting Units may also be interchanged physically within the instrument. The second and first digit Counting Units, including storage binaries, are mounted on one etched circuit board as previously mentioned. The schematic for each Counting Unit is illustrated in Section VII of this manual.

4-171. Each counting binary, shown logically in Table 4-1, requires a positive current pulse applied to either side of the binary to cause a change in state. Inter-binary feedback and feedforward are used to obtain decimal counting of "0" to "9" instead of decimal counting "0" to "15" in a normal four-binary counter with 1-2-4-8 code. The output of each counting binary is controlled by count-up and count-down gates as illustrated in Figure 4-9 enabling each Counting Unit to function as a reversible counter (that is, to count down without passing through zero). The up or down gates are enabled by "count-up" or "count-down" commands (approximately -30 volts) from the Counter Driver Assembly (A16).

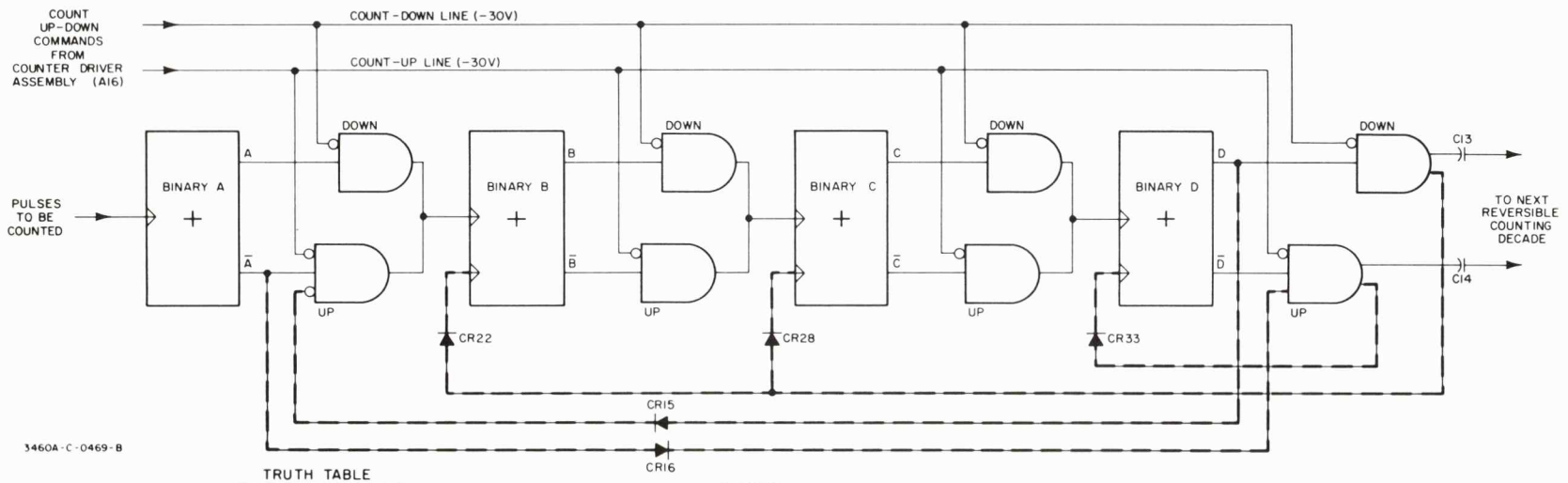
4-172. TRUTH TABLE.

4-173. The truth table on Figure 4-9 and each Counting Unit schematic in Section VII identifies the ten combinations of conducting transistors needed to obtain the ten digital displays identified in the table. Each combination corresponds to one digital display. The plain letters (A, B, C, and D) in the truth table indicate a "1" state for the corresponding binaries and that the transistors assigned the plain letters are conducting illuminating the A, B, C, and D neon lamps respectively. The overscore letters ($\overline{A}$, $\overline{B}$, $\overline{C}$, and $\overline{D}$), read as "A bar" or "not A" etc., indicate a "0" state for the corresponding binaries and that transistors assigned the overscore letters are conducting illuminating the $\overline{A}$, $\overline{B}$, $\overline{C}$, and $\overline{D}$ neon lamps respectively. A binary in the "1" state results in the plain lettered output being true (approximately 0 volts). A binary in the "0" state results in the overscore letter being true.

4-174. RESET.

4-175. The "reset to 0" signal from the Counter Driver Assembly (A16) applied to all Counting Units is approximately 10 μ sec in duration with an amplitude of -28 volts. The "reset to 0" signals are controlled by "counter reset initiate" and "low sensitivity" signals from the Timing and Control Assembly as discussed in Paragraph 4-91 and illustrated on the Detailed Block Diagram, Figure 7-2. The Counter Driver Assembly also disables the count-up and count-down lines during counter reset to prevent any carry pulses. A "reset to 0" signal resets all respective Counting Units to the "0" state resulting in the $\overline{A}$, $\overline{B}$, $\overline{C}$ and $\overline{D}$ transistors conducting (0 display).

4-176. The count-up and count-down gates for each Counting Unit illustrated in Figure 4-9 are all positive true logic AND Gates, however, the output will be positive only after all inputs have been negative simultaneously for a sufficient period of time to permit the coupling capacitor to the next counting binary to charge up through a resistor (47 K) on the count-up or count-down line, whichever one is at -30 volts, and a 3900 ohm resistor to ground. The positive output signal is generated when the coupling capacitor discharges through one of the two coupling diodes to the next counting binary.



TRUTH TABLE

BINARY A (1)	BINARY B (2)	BINARY C (4)	BINARY D (8)	DISPLAY
$\bar{A}$	$\bar{B}$	$\bar{C}$	$\bar{D}$	= 0
A	$\bar{B}$	$\bar{C}$	$\bar{D}$	= 1
$\bar{A}$	B	$\bar{C}$	$\bar{D}$	= 2
A	B	$\bar{C}$	$\bar{D}$	= 3
$\bar{A}$	$\bar{B}$	C	$\bar{D}$	= 4
A	$\bar{B}$	C	$\bar{D}$	= 5
$\bar{A}$	B	C	$\bar{D}$	= 6
A	B	C	$\bar{D}$	= 7
$\bar{A}$	$\bar{B}$	$\bar{C}$	D	= 8
A	$\bar{B}$	$\bar{C}$	D	= 9

NOTES

1. TRUE A, B, C, AND D OUTPUT CORRESPONDS TO "1" STATE IN EACH BINARY.
2. TRUE $\bar{A}$, $\bar{B}$, $\bar{C}$, AND $\bar{D}$ OUTPUT CORRESPONDS TO "0" STATE IN EACH BINARY.
3. COUNT-UP GATES PASSES "1" TO "0" CHANGES IN PRECEDING BINARY.
4. COUNT-DOWN GATES PASSES "0" TO "1" CHANGES IN PRECEDING BINARY.

Figure 4-9. Typical Four-Binary Reversible Counting Decade (1-2-4-8) Code

4-177. The coupling capacitor for the count up gate discharges when the preceding counting binary changes from the "1" to "0" state and the up line is at -30 volts. For example, when the $\overline{A}$ output goes from -30 volts (false) to 0 volts (true), a positive pulse is coupled to the next binary.

4-178. The coupling capacitor for the count-down gate discharges when the preceding counting binary changes from the "0" to "1" state and the down line is at -30 volts. For example, when the A output goes from a -30 volts (false) to 0 volts (true), a positive pulse is coupled to the next binary.

4-179. COUNTING (1-2-4-8 BCD).

4-180. The counting operation described in the following paragraphs pertains to the 1-2-4-8 BCD Reversible Counting Decade illustrated in Figure 4-9. The 1-2-2-4 BCD counting operation is described in Paragraph 4-206.

4-181. Count-Up.

4-182. To count up (counting in a forward direction), the count-up line is at -30 volts enabling all count-up gates. The count-down line is at 0 volts inhibiting all count-down gates. The count-up and count-down lines are controlled by the count up-down control circuit on the Counter Driver Assembly (A16). Refer to the discussion on the Counter Driver Assembly for additional information on count-up and count-down enabling.

4-183. For the first nine pulses (1 thru 9), the Counting Unit operates as a normal binary counter. After the ninth pulse, binaries B and C are in the "0" state and binaries A and D in the "1" state, transistors A, $\overline{B}$, $\overline{C}$ and D conducting. The output from the $\overline{A}$ transistor (cutoff) removes a zero volt clamp applied to binary D count-up gate through feedforward diode CR16. With the clamp removed and binary D in the "1" state ($\overline{D}$ output at -30 volts), capacitor C18 charges up through R54 and R67. When the tenth pulse is applied, binary A returns to the "0" state with binaries B and C remaining in the "0" state The positive feedback from binary D through diode CR15 prevents change in binary B during the tenth pulse by applying a zero volt clamp to the binary A count-up gate. With binary A set to the "0" state, transistor $\overline{A}$ conducting a zero volt clamp is again applied to binary D count-up gate, through feedforward diode CR16, enabling capacitor C18 to discharge through feedback diode CR33. The feedback through diode CR33 returns binary D to the "0" state resulting in a "0" display with $\overline{A}$, $\overline{B}$, $\overline{C}$, $\overline{D}$ true. After the tenth pulse, all binaries are in the "0" state (same as reset condition) and the counting operation described above repeats for any additional pulses received by the respective Counting Unit. Capacitor C14 couples the "1" to "0" change in binary D to the next Counting Unit in the form of a positive going pulse.

4-184. Count-Down.

4-185. To count down (counting in a reverse direction), the count-down line is at -30 V enabling all count-down gates. With the count-down gates enabled, the signals from the opposite side of the binaries are used to perform the counting operation. The counting binaries are triggered to the opposite state with a "0" to "1" change in the preceding binary enabling the Counting Unit to count down, one count for each pulse received, from the last total count.

4-186. Normal binary counting is performed when counting down from "9" to "1." Counting down from zero (zero display) to "9" is described in the following paragraph.

4-187. With zero counts in the Counting Unit, binaries A, B, C, and D are in the "0" state with the respective digital display indication "0." With binary D in the "0" state (D output at -30 volts) and the count-down line at -30 volts, capacitor C17 charges up through resistors R53 and R68. When a pulse is received at the input of the Counting Unit to change the count from "0" to "9," all binaries change to the "1" state through normal binary counting. With binary D in the "1" state, D transistor conducting, the output of the count-down gate for binary D is clamped to zero volt and capacitor C17 discharges through feedback diodes CR28 and CR22. The feedback through CR28 and CR22 returns binaries B and C to the "0" state enabling the digital display to indicate "9." When binary D changes from the "0" state to the "1" state, capacitor C13 couples a positive-going signal to the next Counting Unit.

4-188. DIGITAL DISPLAY.

4-189. The total number of pulses counted by each Counting Unit during one reading period is converted from the binary coded representation within the counting binaries to a digital display using the neon lamps (DS1A thru H) in the collector circuits of each binary, the photoconductor matrix (V1) and the digital display tube (DS2) shown on the schematics. The neon lamps require approximately 70 volts to ionize (fire) and approximately 55 volts to sustain illumination. The diodes connected between the neon transfer line and the collectors of each counting binary make it possible for the neons to store and display the previous reading while the counting binaries count the pulses during the next reading period. The diodes clamp the collector side of the neon lamps to approximately zero volts with the absence of the "neon transfer" command. The clamp holds the ionized neon lamps on and the dark neon lamps off regardless of the states in the counting binaries. At the end of each reading period, the "neon transfer" command (approximately -30 volts) reverse biases the diodes and the neon lamps change states, if necessary, according to the states of the counting binaries. The neon lamps associated with the conducting transistors ionize, and the photocells, in the photoconductor matrix, vertically aligned above the ionized lamps are illuminated. The illuminated photocells constitute a circuit path to light the proper digit in the

digital display tube, DS2. The digital display will correspond to the total number of pulses represented in binary code within the counting binaries. See Note 6 on schematics for the circuit path in the photoconductor matrix necessary to light a numeral in the digital display tube.

4-190. OVERLOAD SIGNAL AMPLIFIER.

An overload signal is generated during count-up when the total number of pulses counted by the first four digits reaches 1200 counts. The overload signal amplifier on the N_1 and N_2 RCD/D-to-A Coil Drive Assembly (A35) (A13 with (1-2-2-4 Options) generates a negative true "overload" signal when Binary B and A^1 are in the "1" state. A negative true "uprange enable" signal is also generated by the overload signal amplifier during an overload condition. The "uprange enable" signal is applied to the Auto Range Selector Assembly for automatic ranging as discussed in the Detailed Block Diagram theory.

4-191. STORAGE BINARIES.

4-192. The first four digit Counting Units have storage binaries in addition to the counting binaries. The storage binaries are used to drive the D-to-A Relay Assembly (A21). The three conditions of the storage binaries as discussed in paragraphs describing the Timing and Control Assembly (A14) are identified in Table 4-4. The table also identifies the "D/A reset enable/storage" and "D/A transfer/reset" signal levels required for each condition.

4-193. During the "Reset Condition," all storage binaries are in the "0" state with $\overline{A}$, $\overline{B}$, $\overline{C}$, and $\overline{D}$ transistors conducting. With all storage binaries in "0" state, the D-to-A Converter (output voltage) is reset to zero.

4-194. During the "Transfer Condition," the state of each counting binary is transferred to the corresponding storage binary, and the storage binaries drive the reed relays on the D/A Relay Assembly (A21) enabling the D-to-A Converter to convert the total pulses counted by the first four digit Counting Units to an equivalent analog voltage.

4-195. When the "Storage Condition" is initiated at the start of the first and second sample periods, the conducting transistors during the last D/A transfer period are held on. The storage binaries are held in this condition until a reset or transfer condition is initiated. The "Storage Condition" enables the counting binaries to count pulses generated during the first and second sample periods without changing the D-to-A Converter output voltage.

4-196. ZERO DETECT.

4-197. Each Counting Unit produces a negative true "zero detect" signal on the zero detect line when all the counting binaries are in the "0" state (0 display). The zero detect line is at 0 volts when any other numeral is in the Counting Unit.

4-198. The state of each counting binary is detected at the collectors of the plain lettered transistors through diodes CR3, CR10, CR19, and CR27. With the counting binaries in the "0" state, and plain lettered transistors cut off, the potential applied to the anode of the diodes is approximately -30 volts. The diodes and a 47 kilohm resistor on the Counter Driver Assembly (A16) form a negative true AND Gate as illustrated in Figure 4-10. The AND Gate produces a -30 volt output with all counting binaries in the "0" state. The moment any counting binary changes to the "1" state, the zero detect line is clamped through the respective diode and transistor to 0 volts, and the "zero detect" signal is terminated.

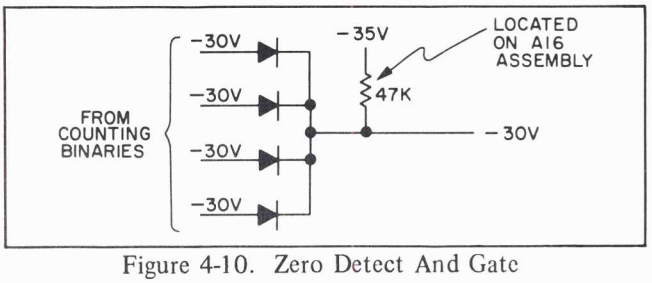


Figure 4-10. Zero Detect And Gate

4-199. The "zero detect" signals are applied to the Counter Driver Assembly, as discussed in paragraphs describing the Counter Driver Assembly, to determine the direction of count. The "zero detect" signals also enable downranging during automatic ranging as described in the Detailed Block Diagram theory.

Table 4-4. Storage Binary Conditions

STORAGE BINARY CONDITION	D/A RESET ENABLE/STORAGE	D/A TRANSFER/RESET	CONDUCTING TRANSISTORS
Reset	0 volts	0 volts	$\overline{A}$, $\overline{B}$, $\overline{C}$, and $\overline{D}$
Transfer	0 volts	-28 volts	See Note
Storage	-28 volts	0 volts	Paragraph 4-180

NOTE

Matches the conducting transistors in counting binaries during D/A transfer period.

4-200. DIGITAL RECORDER OUTPUT.

4-201. A four-line binary-coded decimal (BCD) output is available from each Counting Unit. A voltage representing the state of each binary is taken from the collector of each of the plain lettered transistors (A, B, C, and D). A binary "1" state is represented by a relatively positive voltage, and a binary "0" state is represented by a relatively negative voltage ("1" state positive). See Table 1-1, Specifications, for voltage levels and source resistance of the BCD output. To protect the Counting Unit from being affected by the load, each output line includes a 100 kilohm series-connected isolation resistor.

4-203. The BCD information for polarity, decimal location and overload comes from the Automatic Range Selector Assembly (A41) and the DC Enable Assembly (A44). For additional information on BCD output see illustration in Section VII.

4-204. CODE CONVERTER.

4-205. The first and second digit counting unit, Assembly A35 (or A13 for 1-2-2-4 instruments), contain a code converter. The code converter is used to convert the 1-2-4-8 or 1-2-2-4 code from the storage binaries to a 1-2-4-4 code. The 1-2-4-4 code supplies the unique conditions necessary to drive the appropriate reed relays in the D-to-A converter in order to provide the 20% overranging capability of the 3460B.

4-206. COUNTING (1-2-2-4 BCD).

4-207. Counting binaries for the 1-2-2-4 BCD output are shown in an ABDC sequence on the schematics to increase clarity in showing signal flow.

4-208. During a count-up condition, the first three input pulses are counted normally by the A and B binaries. As the C binary is triggered by the B binary on the fourth input pulse, it retriggers B binary through feedback diodes CR30 and CR15 to its original state and the D binary to the "0" state through feedback diodes CR30 and CR22. The inter-binary feedback, as described after the fourth input pulse, skips the Counting Unit ahead to the state it would normally be in after the sixth input pulse. Normal binary counting continues for the fifth input pulse. On the sixth input pulse, B binary triggers D binary through CR23 without affecting the state of the C binary, thus skipping the Counting Unit ahead to the state it would normally have been in after the twelfth input pulse. Counting continues normally for four more (seventh, eighth, ninth, and tenth) input pulses and returns the Counting Unit to a "0" display and produces an output pulse for application to the next Counting Unit.

4-209. POWER SUPPLIES.

4-210. The -hp- Model 3460B Digital Voltmeter contains eight regulated and three unregulated power supplies which are divided into two groups, one group outside the instrument guard, called the Out-Guard Power Supply, and another group inside the guard (see the Detailed Block Diagram, Figure 7-2). The power supplies outside the guard are referenced to the power-line ground and supply operating power only to the circuits outside the guard. The supplies inside the guard are isolated from the power-line ground, the guard and each other; each is individually referenced to the circuit section it serves inside the guard. The "common point" for each circuit section, to which a power supply is referenced, is critical, and is identified on the Detailed Block Diagram, schematics and Assembly Location Diagram by a number enclosed in a triangle.

4-211. Each power transformer winding for an in-guard power supply is double shielded from the other winding and the core, and is connected to the supply it serves through a double-shielded cable. The shield closest to the winding is brought out and connected through the inner cable-shield to the "common point" of the supply it serves. The outer shield is brought out and connected to the guard through the outer cable-shield.

4-212. There are six power supplies inside the guard divided between three power supply assemblies:

a. The Reference Power Supply Assembly (A19) that generates a precise voltage, either polarity of which may be referenced to the LOW INPUT binding post.

b. The Plus and Minus 25 Volt Power Supply Assembly (A4) is referenced to the Voltage-to-Current Converter chassis whose potential differs from LOW by a voltage proportional to the voltage being measured. The Plus and Minus 25 Volt Power Supply also generates an unregulated +300 volts for the Photochopper Assembly (A5A1).

c. The Plus and Minus 17.5 Volt Power Supply (A3) is referenced to the Integrator and Precision Current-pulse Generator chassis whose potential differs from the Voltage-to-Current Converter chassis by a voltage proportional to the voltage developed across the Sensitivity Resistor(s) on the Input Range and Sensitivity Assembly (A43).

4-213. The Out-Guard Power Supply Assembly (A18) outside the guard contains five power supplies that generate the following voltages:

a. Regulated -17, -35, and +10 volts.

b. Unregulated +150 and -150 volts.

4-214. GUARDING.

4-215. Guarding is an electrical procedure for reducing ground loops and the effects of common mode voltage during precision voltage measurements. Common mode voltage results when the signal source ground and the digital voltmeter ground are at different potentials. The potential difference between these two grounds is known as a common mode voltage source. The largest and most common source of common mode voltage is power-line frequency ripple caused by magnetic fields that produce IR drops across sheet metal and/or wiring. Unless precautions are taken, the common mode voltage source will cause unwanted current flow in the resulting ground loop(s) through the signal source impedance, causing a significant error in a voltage measurement. A very effective solution to this problem is to break the common mode ground loop by using a technique known as guarding, in which the input and measuring circuits of the digital voltmeter are completely isolated from the chassis and its associated ground.

4-216. UNGUARDED VOLTMETER.

4-217. Figure 4-11 illustrates a typical unguarded circuit where the common mode voltage source is represented by Ecm. The ground loop resistance is represented by Rg. The ground loop currents of concern are those through the LOW INPUT side of the voltmeter, that is the current through C1, R1, Rg and Rc as indicated in Figure 4-11. A small current flow in this loop can cause significant errors when making highly accurate measurements. Current through the HIGH INPUT side is insignificant because of the high input impedance.

4-218. GUARDED VOLTMETER.

4-219. Figure 4-12 illustrates the guarding of the -hp- Model 3460B Digital Voltmeter where the common mode ground loop is broken by using a guard shield to isolate the measuring circuits from chassis ground. For a guarded measurement, the guard shield is connected, through the front or rear GUARD connection, to the reference point of the circuit being measured with a low resistance test cable. With GUARD connected as shown in Figure 4-12, the common mode current is effectively shunted away from the measuring circuits and flows through Rg and C2 and no longer effects the accuracy of the measurement. The 3460B achieves a common mode rejection (ratio of common mode signal to its effect on digital display) of over 120 dB at 60 Hz when used in the manner illustrated in Figure 4-12 with Rc resistance less than 1000 ohms. The Rc resistance is known as the unbalance resistance.

4-220. DRIVING THE GUARD.

4-221. In some measuring condition, a true reference point does not exist as illustrated in Figure 4-13. The various precision resistors (Rp) in the figure are being compared by measuring the voltage drop across each one. Connecting the GUARD as shown reduces the effect of the ground loop between the DC Supply and the digital voltmeter but a new problem arises. A dc leakage path exists between the circuit ground and guard shield through Rp and R1 as shown in Figure 4-13. Figure 4-14 illustrates a solution to the problem by driving the guard. Adding four reference resistors (Rr) close to the same value in parallel with the precision resistors (Rp) and connecting the guard to the matching point on the reference resistors, causing the GUARD and LOW connection to be at the same potential,

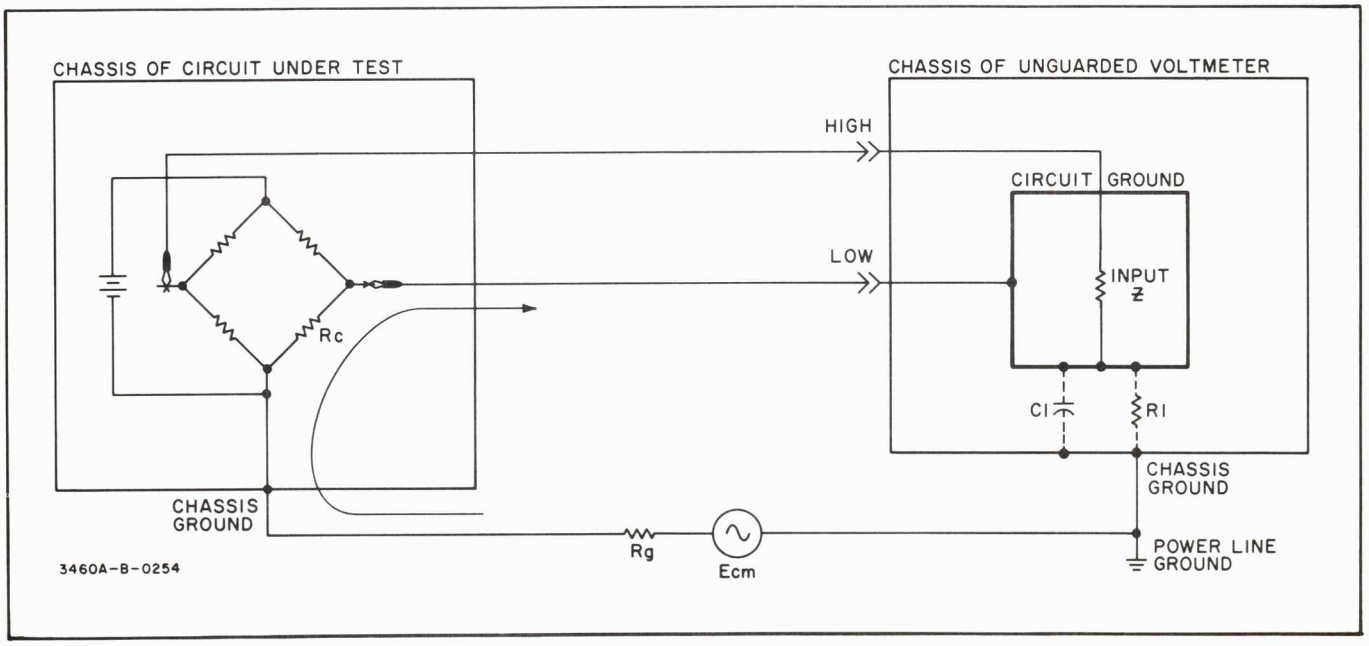


Figure 4-11. Unguarded Measurement

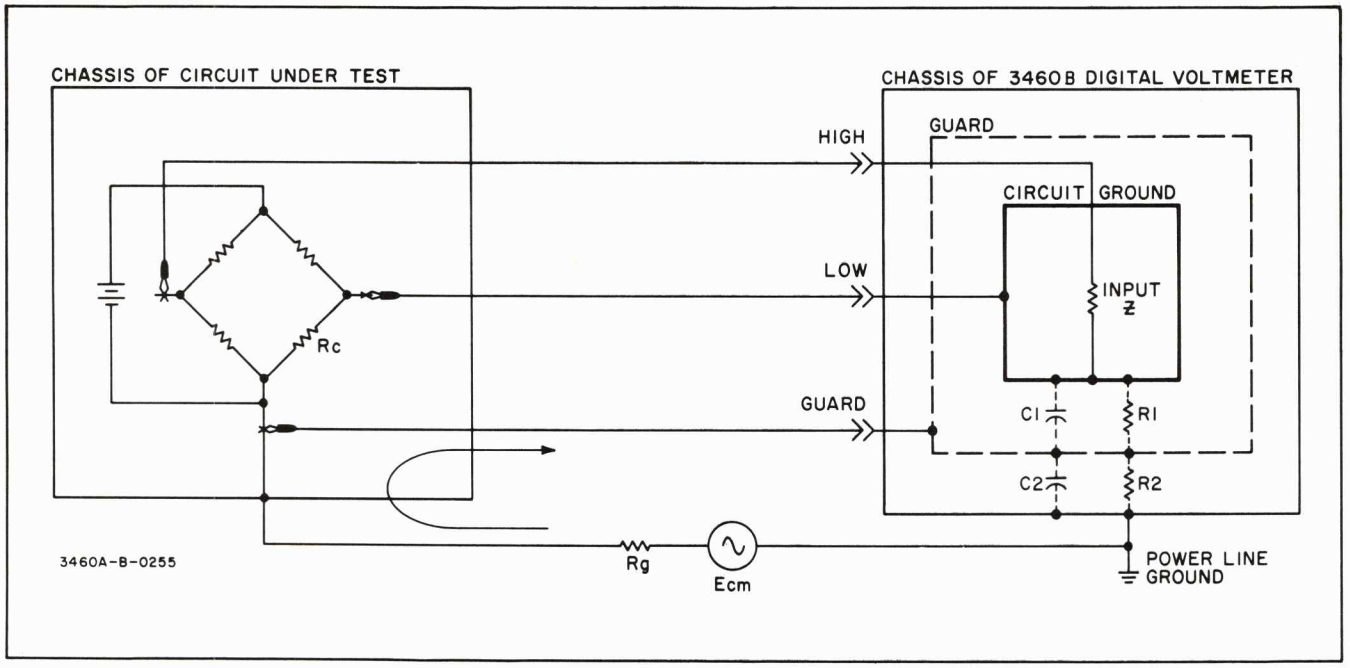


Figure 4-12. Guarded Measurement

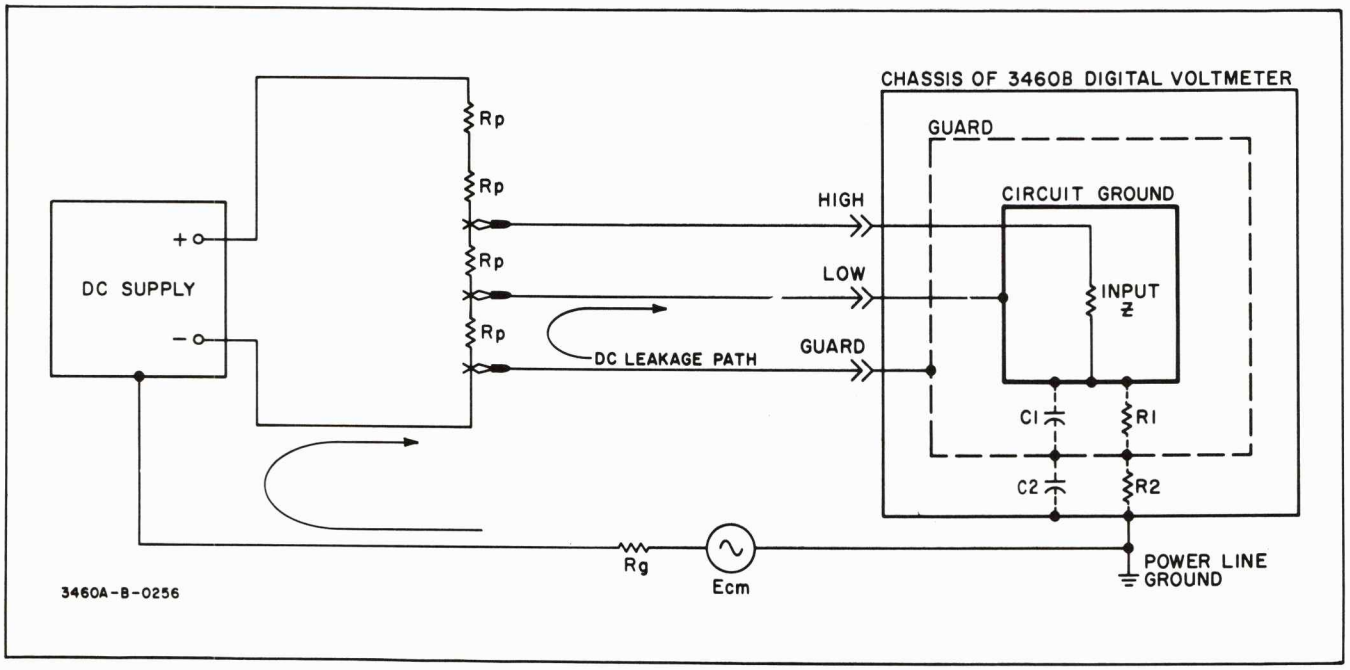


Figure 4-13. Guard Connection With No Source Reference

is an example of driving the guard. This connection effectively shunts the common mode current as shown in Figure 4-14 and the dc leakage path no longer exists.

CAUTION

WHEN DRIVING THE GUARD, THE GUARD AND LOW INPUTS MUST BE CONNECTED AT THE SAME TIME. OTHERWISE, DAMAGE TO THE 3460B MAY RESULT, IF THE POTENTIAL DIFFERENCE BETWEEN GUARD AND LOW EXCEEDS 50 VOLTS AT ANY GIVEN TIME. THE RECOMMENDED PROCEDURE, WHEN DRIVING THE GUARD, IS TO REMOVE THE DC SUPPLY OR SOURCE OPERATING POWER BEFORE MAKING ANY VOLTMETER CONNECTIONS.

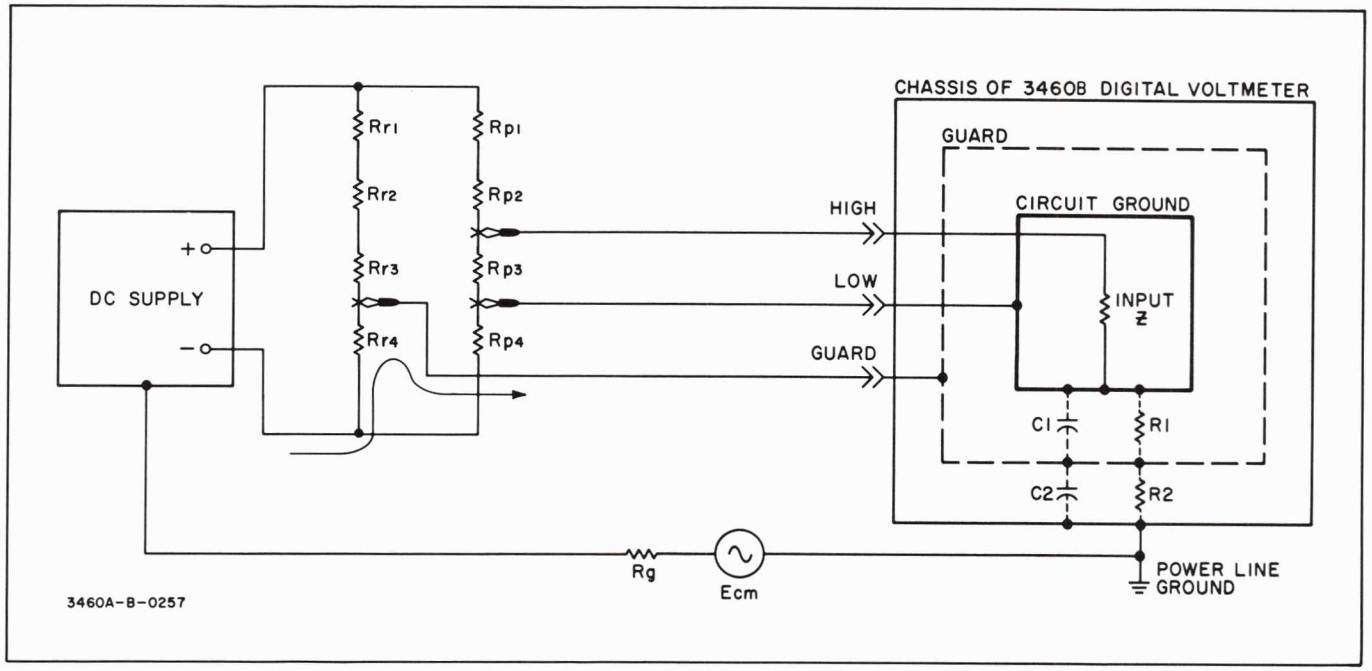


Figure 4-14. Driving the Guard

4-222. Similar techniques as illustrated in Figures 4-12 and 4-14 are used in solving ground loop(s) and common mode voltage problems; however, when driving the GUARD, never apply more than 50 V between GUARD and LOW. When using GUARD, determine the possible common mode current loop(s), the possible dc leakage path(s), and connect the GUARD to a suitable reference point to shunt out the common mode current and dc leakage.

4-223. GUARD CONSTRUCTION.

4-224. Guarding in the Model 3460B consists of a chassis (Guard Assembly, see Figure 7-1) that is electrically isolated from both the voltmeter chassis and the chassis within the Guard Assembly. Electrical isolation is achieved by mounting the Guard Assembly with nylon spacers. The chassis mounted within the Guard Assembly are mounted using the same technique. Using this technique, the guard chassis is isolated by 10^9 ohms from the main chassis of the voltmeter, and the assemblies within the Guard Assembly are also isolated by 10^9 ohms from the guard chassis. Specially constructed transformers, using double shields, are used to supply ac power to the circuits within the guard shield and to couple signals through the guard shield.

Table 5-1. Test Equipment Required

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
DC Standard	Accuracy: (±0.002% of setting ±0.0004% of range) (see Note under Paragraph 5-4)	Performance Checks Adjustment and Calibration Troubleshooting	-hp- Model 740B DC Standard/Differential Voltmeter
1000:1 Divider (see Figure 5-1)	Accuracy: adjustable to 0.001% (see Figure 5-1)	Performance Checks Adjustment and Calibration	Adjustable Standard Resistors
Null Meter	Range: 3 μV Accuracy: ±0.1 μV at null	Performance Checks Adjustment and Calibration	-hp- Model 419A DC Null Voltmeter
1 Volt Standard	Accuracy: 0.001%	Performance Checks Adjustment and Calibration	-hp- Model 735A DC Transfer Standard
Oscillator	Accuracy: ±2% Output: 20 V rms open circuit	Performance Checks	-hp- Model 200CD Wide Range Oscillator
AC Voltmeter	Accuracy: ±2% Frequency: 60 Hz	Performance Checks	-hp- Model 403B AC Voltmeter
Electronic Counter	Accuracy: 0.003% Frequency: 60 kHz	Performance Checks Adjustment and Calibration	-hp- Model 5233L Electronic Counter
Function Generator	Dial Accuracy: ±1% Output: 20 V p-p square wave Frequency: 15 Hz	Performance Checks	-hp- Model 3300A/3301A Function Generator
Oscilloscope	Sensitivity: 100 mV/cm Sweep: 5 μ sec/cm	Performance Checks Adjustment and Calibration Troubleshooting	-hp- Model 140A Oscilloscope
Digital Recorder	Nine columns	Performance Checks	-hp- Model 562A Digital Recorder
Digital Voltmeter	Accuracy: ±0.05% ±1 digit	Adjustment and Calibration	-hp- Model 3440A/3441A Digital Voltmeter
DC Voltmeter	Accuracy: ±1% Input Resistance: 200 megohms	Troubleshooting	-hp- Model 412A DC Voltmeter
Variable Line Transformer	Voltage Range: 103-127 Vac Power Capability: 60 watts	Performance Checks	Superior Type VC1M
1 Megohm Resistor	Accuracy: ±0.01% 1/4 W	Performance Checks	-hp- Part No. 0811-0202
100 kilohm Resistor	Accuracy: ±10% 1 W	Performance Checks	-hp- Part No. 0690-1041
Shielded 10 kilohm Resistor	See Figure 5-4	Performance Checks	- - - - -
5 μF Capacitor	Accuracy: ±10% 100 V dcw	Performance Checks	-hp- Part No. 0170-0057
620 Ohm Resistor	Accuracy: ±5% 1/2 W	Performance Checks	-hp- Part No. 0686-6215
Rosin Core Solder	Low Flux Content	Servicing	-hp-Part No. 8090-0098

NOTE

A Remote Control Cable is required for some checks and adjustments. Use -hp- Model 11085A or build one using a 36 pin male connector, -hp- Part No. 1251-0085.

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains the necessary service information required to properly maintain the -hp- Model 3460B Digital Voltmeter. Included are In-Cabinet Performance Checks, Adjustment and Calibration Procedures, Servicing and Troubleshooting.

5-3. TEST EQUIPMENT REQUIRED.

5-4. The test equipment required to perform the operations outlined in this section is listed in Table 5-1. This table includes the type of instrument required, critical specifications, use, and recommended model. If the model recommended is not available, equipment which meets or exceeds the critical specifications listed may be substituted.

NOTE

When using the DC Standard (-hp- Model 740B), the dc zero offset must be reduced to a minimum (< 2 ppm) using a Null Meter with a 3 μ V range.

5-5. IN-CABINET PERFORMANCE CHECKS.

5-6. The performance checks described in Paragraphs 5-7 through 5-18 are front panel procedures designed to compare the Model 3460B with its published specifications. These tests may be incorporated in periodic maintenance, post repair, and in coming quality control checks. The performance checks should be conducted before any attempt is made to adjust or calibrate the instrument. During the In-Cabinet Performance Checks, the Model 3460B Digital Voltmeter should be connected to the ac line through a variable voltage device so that line voltage may be varied ±10% from 115 or 230 Vac to assure that the instrument operates correctly at various ac line voltages.

NOTE

Allow a 15-minute warm-up and stabilization period before conducting any performance check.

5-7. ACCURACY AND LINEARITY CHECK.

a. Figure 5-1 illustrates the test arrangement recommended. A DC Standard (-hp- Model 740B), 28 Adjustable Standard Resistors, a Null Meter (-hp- Model 419A) and a DC Transfer Standard (-hp- Model 735A) are required for this test.

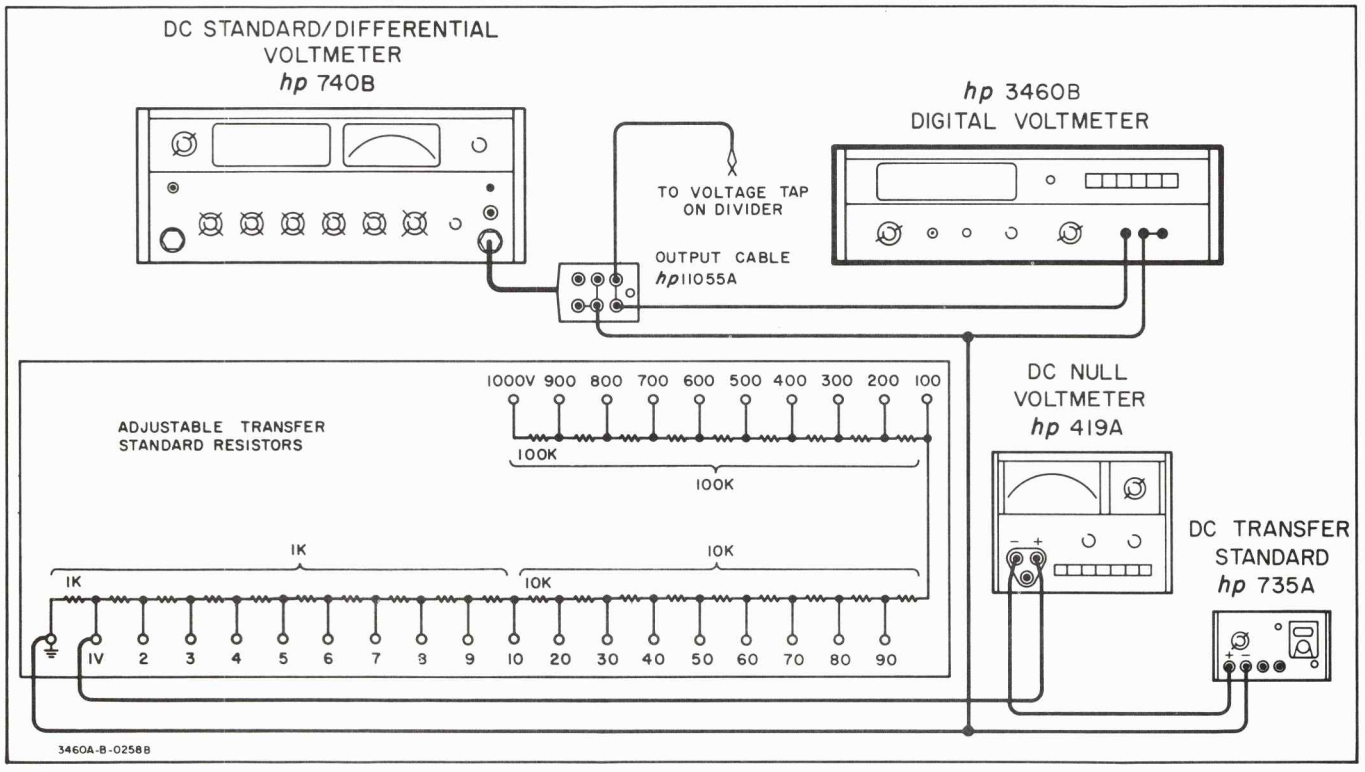


Figure 5-1. Accuracy and Linearity Check

b. Connect the Model 3460B as shown in Figure 5-1, and set controls as follows:

LOCAL-REMOTE TRIGGERING ... LOCAL
TRIGGERING RATE .....MAX. CW
RANGE .....1 Volt
REAR-FRONT ..... FRONT
LOW-to-GUARD shorting bar ..... Connected

c. Connect the HIGH INPUT of the Model 3460B and the high side of the dc standard output to the 1 V tap on divider.

d. Adjust dc transfer standard for 1.000 V output.

e. Adjust dc standard output until null meter indicates a null on the 3 μV range.

f. Verify 3460B digital display indicates 1.00000 V ±6 counts.

g. Continue accuracy test using settings provided in Table 5-2. Connect Model 3460B and dc standard to voltage tap indication. DC Standard output must be adjusted each time for null. Model 3460B should indicate voltages within limits specified in Table 5-2.

Table 5-2. Accuracy Test

RANGE MODEL 3460B	VOLTAGE TAP ON DIVIDER	MODEL 3460B DISPLAY
10 V	9 V	8.9995 to 9.0005 V
100 V	90 V	89.995 to 90.005 V
1000 V	900 V	899.95 to 900.05 V

h. If the Model 3460B does not meet the above specifications, refer to Paragraph 5-19 for proper calibration procedure.

j. To check the Model 3460B linearity, set the RANGE to 10 V. Connect Model 3460B and dc standard to 9 V tap on divider.

k. Adjust dc standard for null indication on null meter. Model 3460B should indicate 9.0000 ±5 counts.

m. Repeat steps j and k above using the voltage taps on divider listed in Table 5-3. DC Standard must be adjusted each time for null. Model 3460B should indicate as specified in Table 5-3.

NOTE

The First Digit is an overload digit that remains blank except for full-scale and up to 20% over full-scale readings.

Table 5-3. Second Digit Linearity Test

MODEL 3460B RANGE	CONNECT MODEL 3460B TO VOLTAGE TAP DIVIDER	MODEL 3460B DISPLAY
10 V	9 V	9.0000 ±5 counts
10 V	8 V	8.0000 ±5 counts
10 V	7 V	7.0000 ±4 counts
10 V	6 V	6.0000 ±4 counts
10 V	5 V	5.0000 ±4 counts
10 V	4 V	4.0000 ±3 counts
10 V	3 V	3.0000 ±3 counts
10 V	2 V	2.0000 ±2 counts
10 V	1 V	1.0000 ±2 counts
10 V	short Model 3460B input	0.0000 ±2 counts

p. To check Model 3460B third and fourth digit linearity, apply input voltages listed in Table 5-4 directly from the DC Standard. Model 3460B should indicate as specified in Table 5-4 (±2 counts).

Table 5-4. Third and Fourth Digit Linearity Test

MODEL 3460B RANGE	DC STANDARD OUTPUT	MODEL 3460B DISPLAY
10 V	0.90000	0.9000 V ±2 counts
10 V	0.70000	0.7000 V ±2 counts
10 V	0.50000	0.5000 V ±2 counts
10 V	0.30000	0.3000 V ±2 counts
10 V	0.10000	0.1000 V ±2 counts
10 V	0.09000	0.0900 V ±2 counts
10 V	0.07000	0.0700 V ±2 counts
10 V	0.05000	0.0500 V ±2 counts
10 V	0.03000	0.0300 V ±2 counts
10 V	0.01000	0.0100 V ±2 counts

q. If Model 3460B does not meet the above specifications, refer to Paragraph 5-19 for proper calibration procedure.

5-8. AUTOMATIC RANGING CHECK.

a. A DC Standard (-hp- Model 740B) is required for this test.

b. Set Model 3460B LOCAL-REMOTE TRIGGERING Selector to LOCAL; depress AUTO RANGE pushbutton; position TRIGGERING RATE to HOLD, and FRONT-REAR Switch to FRONT.

c. Connect DC Standard output to Model 3460B INPUT.

d. Adjust DC Standard output for 121.00 volts.

e. Depress the 3460B TRIGGERING Pushbutton and verify 3460B up-ranges to 1000 V range.

f. Disconnect DC Standard; depress the 3460B TRIGGERING Pushbutton twice and verify 3460B downranges to 1 V range.

5-9. INPUT RESISTANCE CHECK.

a. A DC Standard (-hp- Model 740B) and a 1 megohm 0.01% resistor (-hp- Part No. 0811-0202) are required for this test.

NOTE

The third digit linearity error noted in Table 5-4 should be taken into account when performing this check.

b. Set Model 3460B controls as follows:

LOCAL-REMOTE TRIGGERING ... LOCAL
TRIGGERING RATE .....MAX. CW
RANGE .....100 Volt
REAR-FRONT ..... FRONT

c. Connect DC Standard output in series with 1 megohm resistor to 3460B INPUT.

d. Short out the 1 megohm resistor with jumper lead.

e. Adjust DC Standard output on the 100 volt range for 99.000 V display on 3460B and remove jumper lead.

f. Model 3460B front panel display should indicate 90.000 ±3 counts. This verifies Model 3460B input resistance of 10 megohms ±0.03% where:

$$\text{Input } R = \frac{E_{display}}{E_{in} - E_{display}} \times R$$

E_{in} = 99.000 V

$E_{display}$ = 3460B display in step f

R = series resistor, 1 megohm

g. Adjust 740B output to display 10.0000 V on the 3460B 10 V range with the jumper lead across the 1 megohm resistor.

h. Remove jumper lead. 3460B display should not change more than ten counts to verify an input resistance of greater than 10^{10} ohms.

5-10. DC COMMON MODE REJECTION CHECK.

a. Figure 5-2 illustrates the test arrangement recommended. A DC Standard (-hp- Model 740B) and a 100 kilohm 1 W resistor (-hp- Part No. 0690-1041) are required for this test.

b. Connect Model 3460B as shown in Figure 5-2 and set controls as follows:

LOCAL-REMOTE TRIGGERING ... LOCAL
TRIGGERING RATE .....MAX. CW
RANGE .....1 Volt
REAR-FRONT ..... FRONT
LOW-to-GUARD shorting bar ..... Remove

CAUTION

NEVER APPLY MORE THAN 50 VOLTS BETWEEN LOW AND GUARD WITH SHORTING BAR REMOVED; OTHERWISE, DAMAGE TO REED RELAYS WITHIN MODEL 3460B WILL RESULT.

c. Slowly increase DC Standard output voltage until 500.0 V level is obtained. Note Model 3460B display. Model 3460B should indicate less than

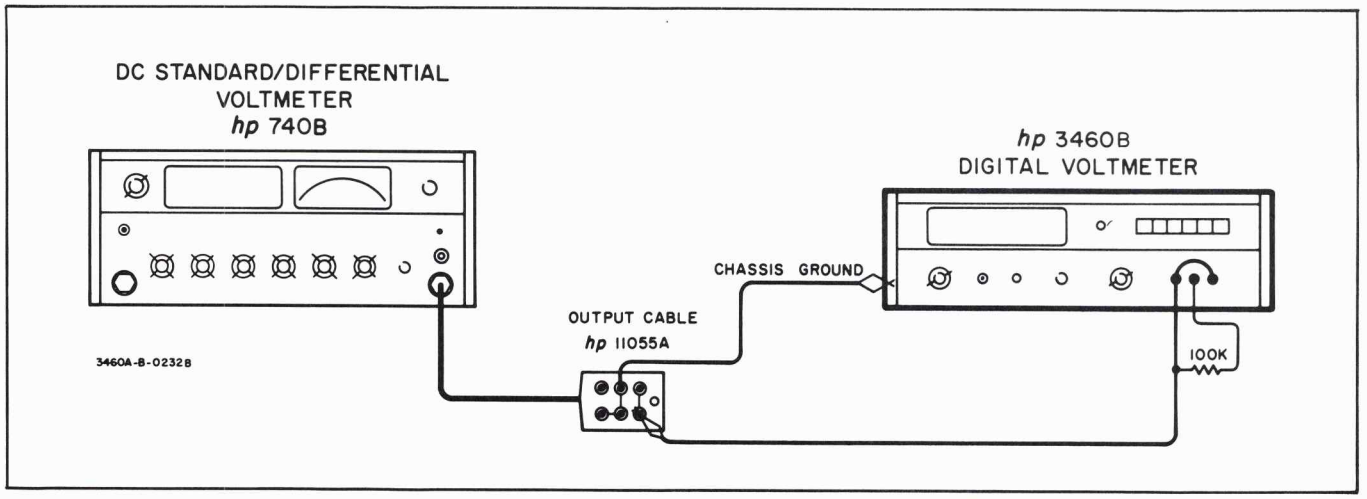


Figure 5-2. DC Common Mode Rejection Check

0.00050 V. This verifies dc common mode rejection of 120 dB with 100 kilohms between Model 3460B LOW INPUT and the point where GUARD is connected, or more than 160 dB with 1 kilohm across the same points, where:

$$CMR_{db} = 20 \log \frac{E_{\text{common mode voltage}}}{E_{\text{effect on digital display}}}$$

d. Disconnect test equipment and connect LOW-to-GUARD Shorting Bar.

5-11. AC COMMON MODE REJECTION CHECK.

a. Figure 5-3 illustrates the test arrangement recommended. An Oscillator (-hp- Model 200CD), an AC Voltmeter (-hp- Model 403B), and a shield (Figure 5-4) are required for this test.

NOTE

The AC Voltmeter must be battery operated.

b. Connect Model 3460B as shown in Figure 5-3 and set controls as follows:

LOCAL-REMOTE TRIGGERING . LINE OFF
REAR-FRONT . . . . . FRONT
LOW-to-GUARD shorting bar . . . . . Remove

c. Set oscillator frequency to 60 Hz; output amplitude for 20 V rms. (Verify with ac voltmeter.)

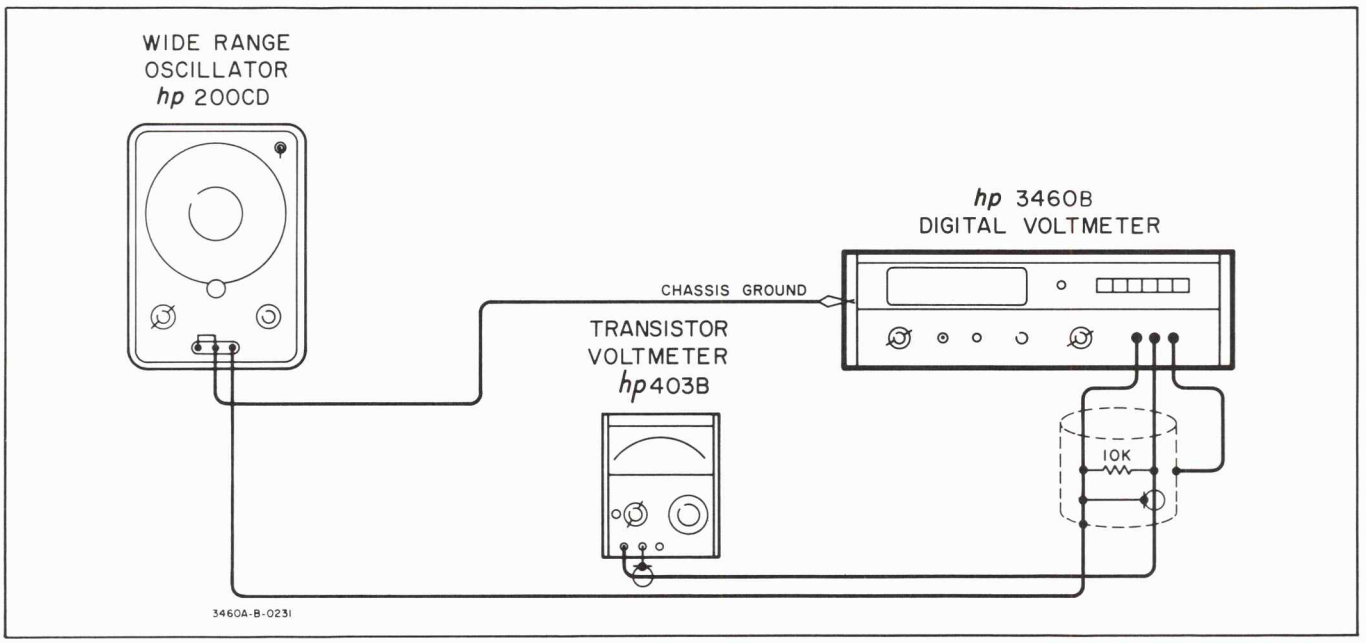
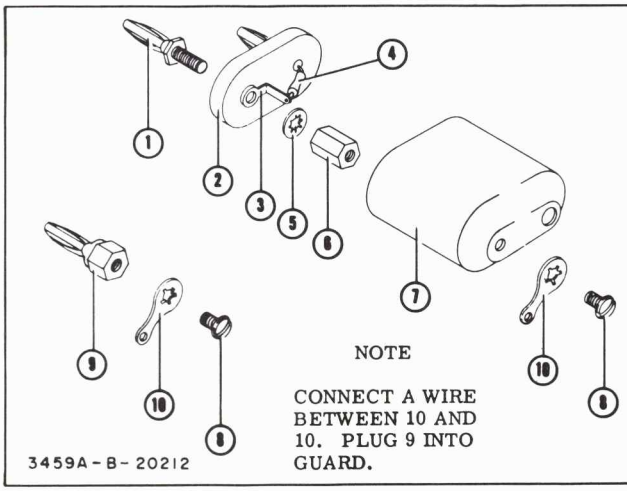


Figure 5-3. AC Common Mode Rejection Check



No.	Description	-hp- Part No.
1	Connector, male	1251-0174
2	Connector, male, w/insulator	1251-0175
3	Lug, terminal 90°	0360-0042
4	Resistor, 10 kilohm, 1/2 W, 1%, metal film	0757-0839
5	Washer, int. lock	2190-0007
6	Spacer, 6-32 threaded	0380-0058
7	Shield	1251-0173
8	Screw, bind. head, 6-32 x 1/4 in.	2470-0001
9	Connector, male	1251-0013
10	Lug, terminal	0360-0001

Figure 5-4. Shield

d. AC Voltmeter should read less than 200 μV. This verifies ac common mode rejection of greater than 120 dB at 60 Hz.

NOTE

AC Voltmeter connections to the 10 kilohm resistor are completed through hole available on the shield illustrated in Figure 5-4. The guard connection is made with a jumper lead from the GUARD INPUT binding post to the screw, ⑧, on the shield. The output of the oscillator is connected to the same point.

NOTE

The same formula in Paragraph 5-10 applies for ac common mode rejection. A 10 kilohm resistor is used in place of a 1 kilohm resistor in order to make the reading in the ac voltmeter more toward mid scale.

e. Disconnect test equipment and connect LOW-to-GUARD shorting bar.

5-12. SUPERIMPOSED NOISE REJECTION CHECK.

a. Figure 5-5 illustrates the test arrangement recommended. An Oscillator (-hp- Model 200CD) and an Oscilloscope (-hp- Model 140A) are required for this test.

b. Connect Model 3460B as shown in Figure 5-5, and set controls as follows:

LOCAL-REMOTE TRIGGERING ... LOCAL
TRIGGERING RATE .....MAX. CW
RANGE .....10 Volt
REAR-FRONT ..... FRONT
LOW-to-GUARD shorting bar ..... Connected

c. Adjust oscillator output for 424 mV rms (600 mV peak) at 60 Hz. Verify with 403B AC Voltmeter.

NOTE

A clicking (reed relay) will be audible within the Model 3460B.

d. Set oscilloscope trigger source to LINE and readjust oscillator frequency for fixed display on oscilloscope.

e. Model 3460B display should indicate ±0.0006. This verifies superimposed noise rejection of greater than 60 dB at 60 Hz having less than 0.1% deviation where:

$$\text{Noise rejection} = 20 \log \frac{E_{\text{superimposed (peak)}}}{E_{\text{effect on digital display}}}$$

NOTE

This check assumes a line deviation from 60 Hz of less than 0.1%. Larger deviation from 60 Hz will result in less rejection. If proper rejection is not achieved, verify oscillator frequency with electronic counter.

5-13. SUPERIMPOSED NOISE REJECTION CHECK (Options 004, 005, 006, 007).

5-14. The following test can be used to evaluate the operation of the 3460B filter.

a. Construct the test setup shown in Figure 5-5.

b. Connect a 5 μF capacitor (-hp- Part No. 0170-0057) in series with the oscillator connection to the 3460B HIGH Input Terminal. The capacitor is used to block any dc on the oscillator output.

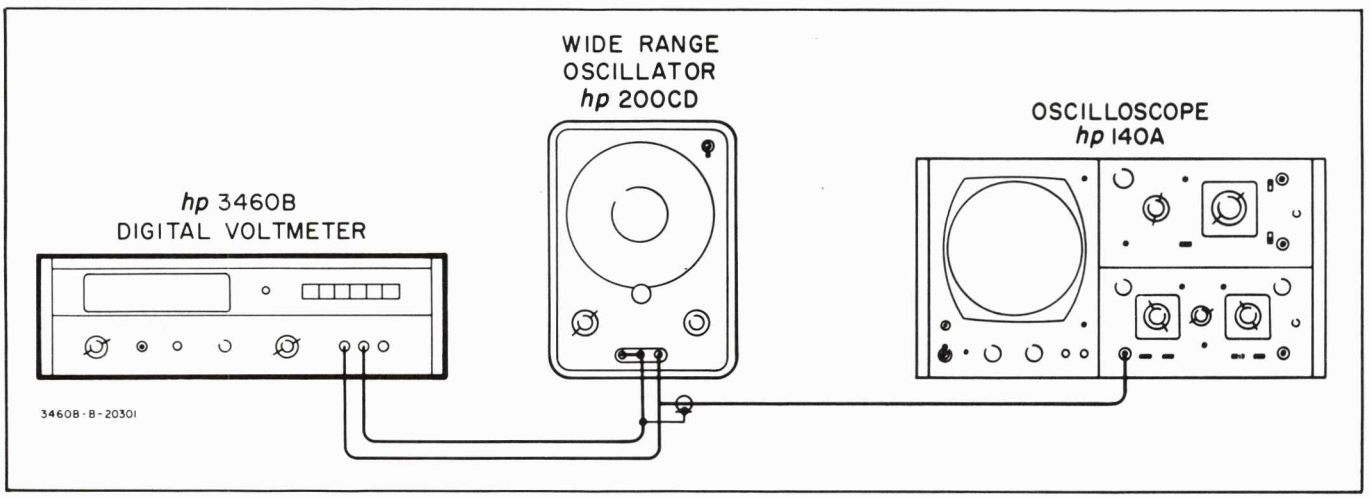


Figure 5-5. Superimposed Noise Rejection Check

c. Connect a 620 ohm resistor (-hp- Part No. 0686-6215) across the HIGH and LOW Input Terminals. The resistor provides an impedance match for the oscillator output.

d. Set the 3460B controls as follows:

LOCAL-REMOTE TRIGGERING ... LOCAL
TRIGGERING RATE .....MAX. CW
RANGE .....1 Volt
REAR-FRONT ..... FRONT

e. Adjust the oscillator for a 1 V peak (2 V p-p) 60 Hz output as indicated on the oscilloscope.

f. Set oscilloscope trigger source to LINE and readjust oscillator frequency for a fixed (non-moving) display on the oscilloscope.

g. 3460B display should indicate .00000 ±.00250.

h. Vary oscillator frequency between 58 Hz and 62 Hz. 3460B display should indicate .00000 ±.00250. This verifies a total noise rejection of 52 dB and verifies that the filter provides 26 dB of additional noise rejection at 60 Hz.

5-15. REMOTE OPERATIONS.

5-16. Remote Ranging.

a. Set Model 3460B controls as follows:

LOCAL-REMOTE TRIGGERING ... LOCAL
TRIGGERING RATE .....MAX. CW
RANGE .....REMOTE
INPUT ..... Open

b. Connect Remote Control Cable Model 11085A to REMOTE CONTROL Connector on rear panel.

c. Remotely range the 3460B by grounding the appropriate pin on the REMOTE CONTROL Connector as identified in Table 5-5.

NOTE

When the remote control pin for automatic ranging is grounded, the 3460B will return to the 1 volt range.

Table 5-5. Remote Ranging

RANGE DESIRED	PIN AND WIRE COLOR
1 V	Pin 30 (Wht/Yel)
10 V	Pin 31 (Wht/Grn)
100 V	Pin 32 (Wht/Orn)
1000 V	Pin 33 (Wht/Brn)
Automatic	Pin 28 (Wht/Blk)

5-17. Remote Triggering (Maximum Reading Rate).

a. Figure 5-6 illustrates the test arrangement recommended. An Electronic Counter (-hp- Model 5233L), a Function Generator (-hp- Model 3300A/3301A), an Oscilloscope (-hp- Model 140A), and a DC Standard (-hp- Model 740B, not shown in figure) are required for this test.

b. Set Model 3460B LOCAL-REMOTE TRIGGERING Selector to REMOTE; RANGE to 10 volts; REAR-FRONT Switch to FRONT.

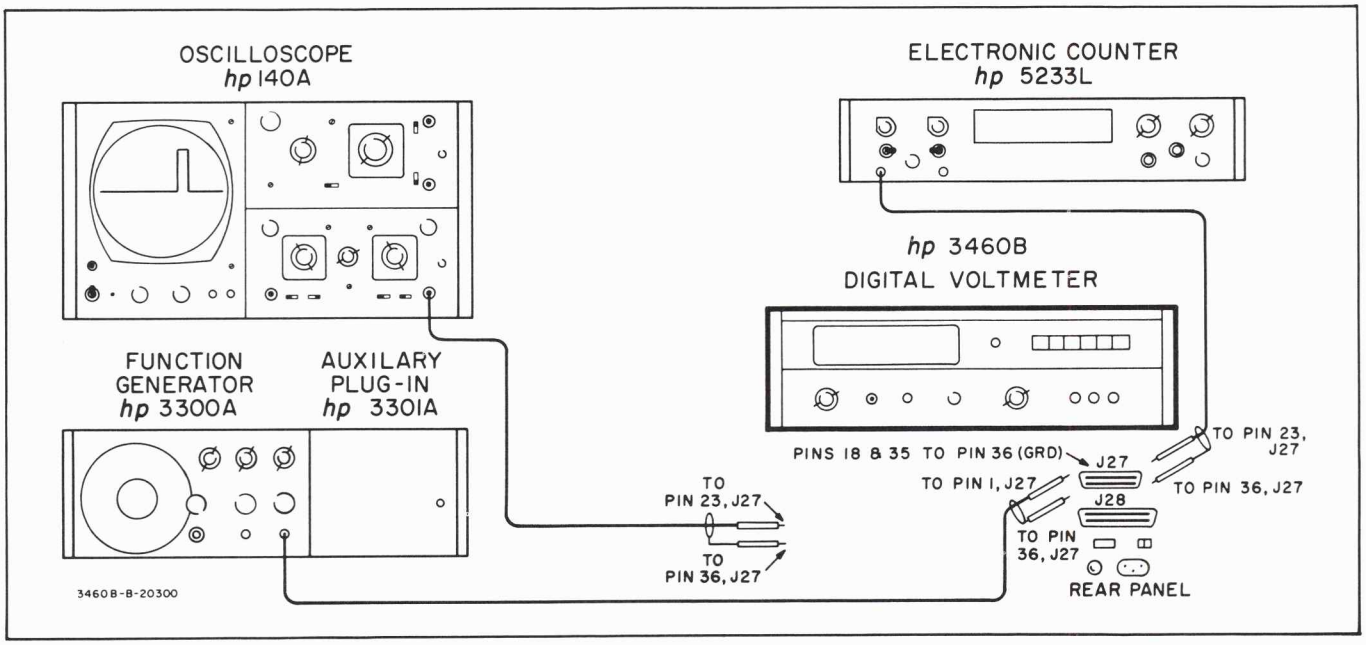


Figure 5-6. Maximum Reading Rate Check

c. Connect Pins 18 and 35 on REMOTE CONTROL Connector to Pin 36 (chassis ground) via the Remote Control Cable. Refer to Table 3-1 for wire color code.

d. Connect the function generator output between Pin 3 on REMOTE CONTROL Connector and chassis ground (Pin 36).

e. Adjust function generator for 15 Hz, 20 V peak-to-peak square wave output. Verify frequency with electronic counter and amplitude with oscilloscope.

f. Connect oscilloscope between REMOTE CONTROL Pin 23 and chassis ground (Pin 36).

g. Connect dc standard output to Model 3460B INPUT and adjust for 9.0000 V output.

h. Observe "print command" waveform on oscilloscope. The total period time of $\simeq$ 50 ms plus $\simeq$ 15 ms verifies a max reading rate of 15 per sec. See Figure 5-6 for proper waveform.

NOTE

50 ms corresponds to minimum reading period. 15 ms corresponds to display period or "program period." The electronic counter may be used in place of oscilloscope in step h.

j. Disconnect test equipment and the Remote Control Cable.

5-18. RECORDER OUTPUT CHECK.

a. A Digital Recorder (-hp- Model 562A or 5050B) and a DC Standard (-hp- Model 740B) will be required for this test. For a 3460B with either 1-2-2-4 or 1-2-4-8 coding, an appropriately coded recorder will be required. (See Page 1-3 for information on 3460B and printer codes.)

b. Connect digital recorder input to Model 3460B RECORDER connector (J28) on the rear panel.

c. Set Model 3460B to LOCAL; RANGE to 1 V; TRIGGERING RATE to MAX. CW.

d. Connect dc standard to Model 3460B INPUT. Adjust standard output for Model 3460B digital display of +0.55555.

e. Digital recorder should print information contained in Table 5-6.

f. Continue check of Model 3460B recorder output by adjusting the dc standard for Model 3460B display listed in Table 5-6, and verify proper printout.

Table 5-6. Recorder Output Check

MODEL 3460B		DIGITAL RECORDER PRINTOUT		
RANGE	DISPLAY	9 8 7 6	5	4 3 2 1
1 V	+0.55555 V	0 0 5 5	5	5 5 0 5
1 V	+1.20100 V*	0 1 2 0	1 or 0	0 0 1 5
10 V	+ 2.2222 V	0 0 2 2	2	2 2 0 4
10 V	+11.1111 V	0 1 1 1	1	1 1 0 4
100 V	- 11.111 V	1 0 1 1	1	1 1 0 3
100 V	-120.100 V*	1 1 2 0	1 or 0	0 0 1 3
1000 V	- 555.55 V	1 0 5 5	5	5 5 0 2
1000 V	- 999.99 V	1 0 9 9	9	9 9 0 2

NOTES

Digital recorder columns in this table are identified as follows (standard print wheel):

Column 9: Function Polarity (0 = +, 1 = -)
Columns 3 thru 8: Model 3460B front panel display
Column 2: Overload indication (1)
Column 1: Decimal location (Negative powers of 10)
* denotes overload

5-19. ADJUSTMENT AND CALIBRATION PROCEDURE.

5-20. The following is a complete adjustment and calibration procedure for the Model 3460B. These operations should be conducted only after it has been established that the Model 3460B does not meet its published specifications. A Preoperational Check and Calibration to verify the internal zero setting and V-to-F Converter linearity is outlined in Paragraph 3-4. Indescriminate adjustment of internal controls to refine readings may actually cause more difficulty. If the following operations do not rectify any discrepancy which may exist, refer to Paragraph 5-61, Troubleshooting, for possible cause and recommended action.

NOTE

Refer to the inside of the top cover for location for all adjustments. Figure 5-7 may also be used to locate adjustments.

CAUTION

THIS INSTRUMENT CONTAINS EXTREMELY HIGH IMPEDANCE CIRCUITS. CERTAIN AREAS WITHIN THE INSTRUMENT MUST BE KEPT FREE FROM CONTAMINATION TO PRESERVE ACCURACY AND PERFORMANCE. THESE AREAS ARE:

1. Input Range and Sensitivity Selector Assembly (A43).

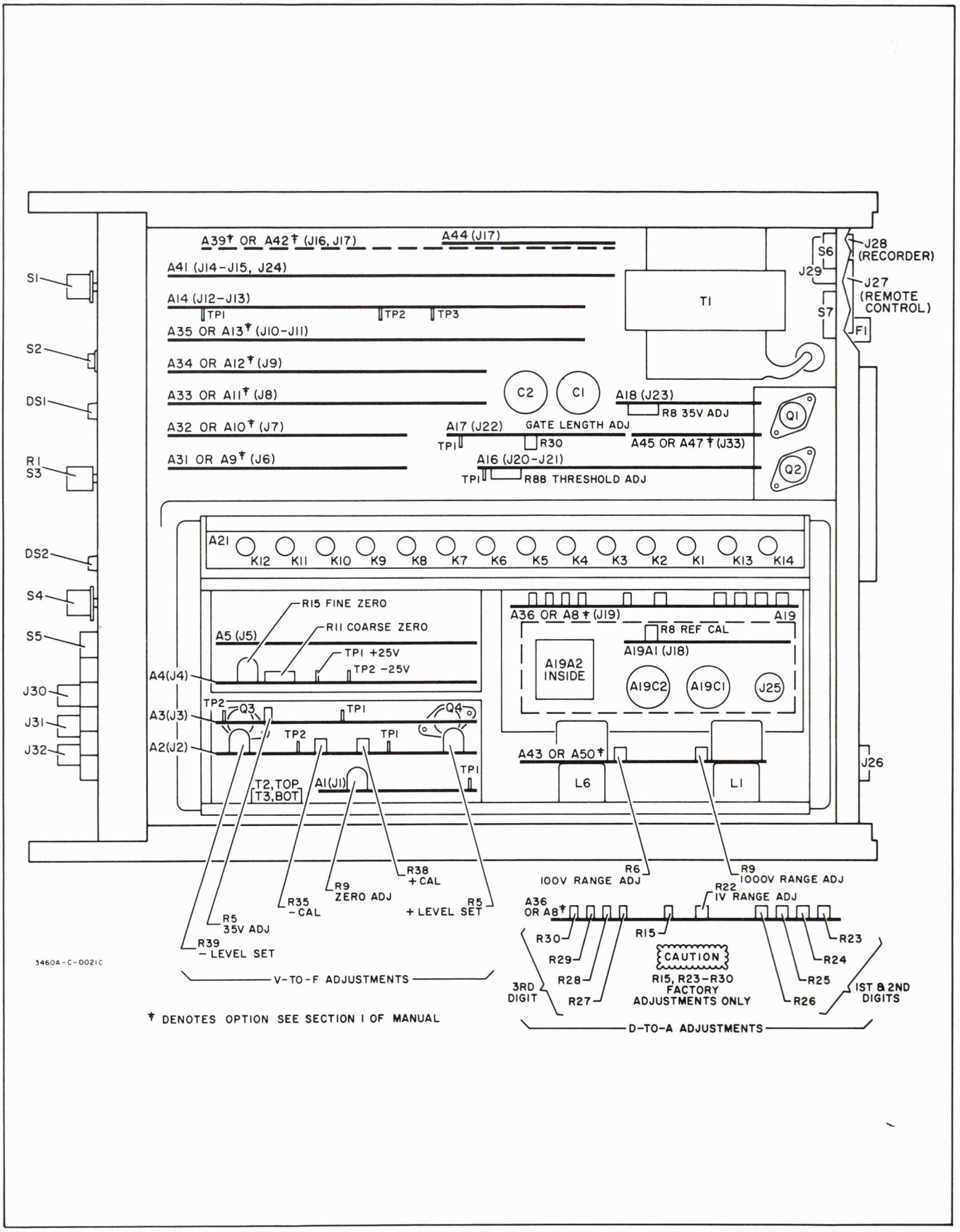


Figure 5-7. Adjustment Point Location

2. Digital-to-Analog Resistor Assembly (A36/A8)

3. Voltage-to-Current Converter Assembly (A5) (particularly the input cable and input connection).

4. REAR-FRONT INPUT switch.

CLEAN RUBBER GLOVES SHOULD BE WORN AT ALL TIMES WHEN WORKING IN OR AROUND THESE AREAS. IN ADDITION, LOW FLUX CONTENT ROSIN CORE SOLDER SHOULD BE USED FOR ALL REPAIR WORK.

5-21. PREPARATION FOR CALIBRATION.

a. Position LOCAL-REMOTE TRIGGERING Selector to LINE OFF and remove the Model 3460B top cover and the support board (MP44) holding the out-guard assemblies in place.

NOTE

Observe CAUTIONS printed on the support board and top guard cover.

b. Remove top guard cover and adjust -LEVEL SET (A2R39) and +LEVEL SET (A2R5) full clockwise (cw).

c. Apply operating power and allow 30 minute warmup and stabilization period before conducting any calibration procedures.

5-22. OUT-GUARD POWER SUPPLY ADJUSTMENT (A18R8).

a. A DVM (-hp- Model 3440A/3441A) is required.

b. Set Model 3460B LOCAL-REMOTE TRIGGERING Selector to LINE OFF, and mount the Out-Guard Power Supply Assembly (A18) on a 15 pin printed circuit board extender.

c. Set Model 3460B LOCAL-REMOTE TRIGGERING Selector to LOCAL, and short the INPUT.

d. Measure the negative dc voltage between pin A, J23 and chassis ground, It should be -35 V (±0.1 V).

e. Adjust 35 V ADJ (A18R8) until proper voltage is obtained.

NOTE

The Out-Guard Power Supply may be checked without using a printed circuit board extender by measuring the -35 volts between chassis ground and the top side of A18R1. Refer to Section VII for component location of A18R1.

5-23. MATCHED ASSEMBLIES A4 AND A5.

Assemblies A4 and A5 are matched; therefore, when replacing or completing repairs to either or both, the following procedure should be performed.

a. A dc voltmeter (-hp- Model 412A) is required.

b. Make sure Model 3460B LINE switch is OFF.

c. Using clean pliers, disconnect the input cable to the A5 assembly, and place the cable in an area free of any electrical connections or contamination.

d. Mount both A4 and A5 assemblies on printed circuit board extenders.

e. Connect A5TP3 and A5TP4 to photochopper block (common point ▽) with two jumper leads.

f. Turn 3460B LINE switch ON. Set RANGE to 10 V, TRIGGERING RATE fully clockwise, and connect LOW-to-GUARD shorting bar.

NOTE

The Model 3460B will indicate overload.

g. Measure voltage between A5 pin 15 and the chassis of the A4 and A5 assemblies (common point ▽).

h. Adjust COARSE ZERO (A4R11) for a dc voltmeter indication as near zero volts as possible.

i. Turn 3460B LINE switch OFF.

j. Remove A4 assembly from extender and insert into J4 within the instrument. Remove jumper leads.

k. Connect the dc voltmeter between A5TP1 and TP2 (low side to TP1).

l. Connect jumper lead between modulator side of A5C10 and the photochopper block (common point ▽).

m. Turn 3460B LINE switch ON.

n. Adjust LEVEL SET (A5R30) for zero volts ±100 mV.

o. Turn off 3460B, remove jumper lead, and replace assembly A5 into J5 within the instrument.

p. Continue the Adjustment and Calibration Procedure.

5-24. IN-GUARD POWER SUPPLY ADJUSTMENT (A3R5).

NOTE

If the In-Guard Power Supply is adjusted, it will be necessary to adjust the V-to-F Converter as outlined in Paragraph 5-27.

a. The Model 3460B should not be used to check its own in-guard power supply, Plus and Minus 17.5 Volt Power Supply (A3). Instead, a DVM (-hp- Model 3440A/3441A) is required.

CAUTION

THE FOLLOWING MEASUREMENT IS NOT REFERENCED TO POWER-LINE GROUND (⏚). THEREFORE, REMOVE THE SHORTING STRAP ON THE 3440A.

b. Connect dc voltmeter between A3TP1 and A3TP2.

c. Adjust 35 V ADJ (A3R5) for 35.0 V (±0.04 V).

5-25. LEVEL SET ADJUSTMENT (A2R5 and A2R39).

a. A DC Standard (-hp- Model 740B) and an Oscilloscope (-hp- Model 140A) are required.

b. Connect dc standard output to Model 3460B INPUT for a + indication on front panel display.

c. Set Model 3460B to LOCAL; RANGE to 10 V; TRIGGERING RATE full clockwise (cw); REAR-FRONT to FRONT.

d. Center oscilloscope trace on graticule. (Check zero offset.)

e. Connect oscilloscope between A1TP1 and LOW INPUT binding post.

f. Set oscilloscope controls as follows:

INPUT	DC coupled
TRIGGER SOURCE	Internal
TRIGGER LEVEL	Negative
TRIGGER SLOPE	Negative

g. Adjust dc standard output for +0.0050 V display on 3460B.

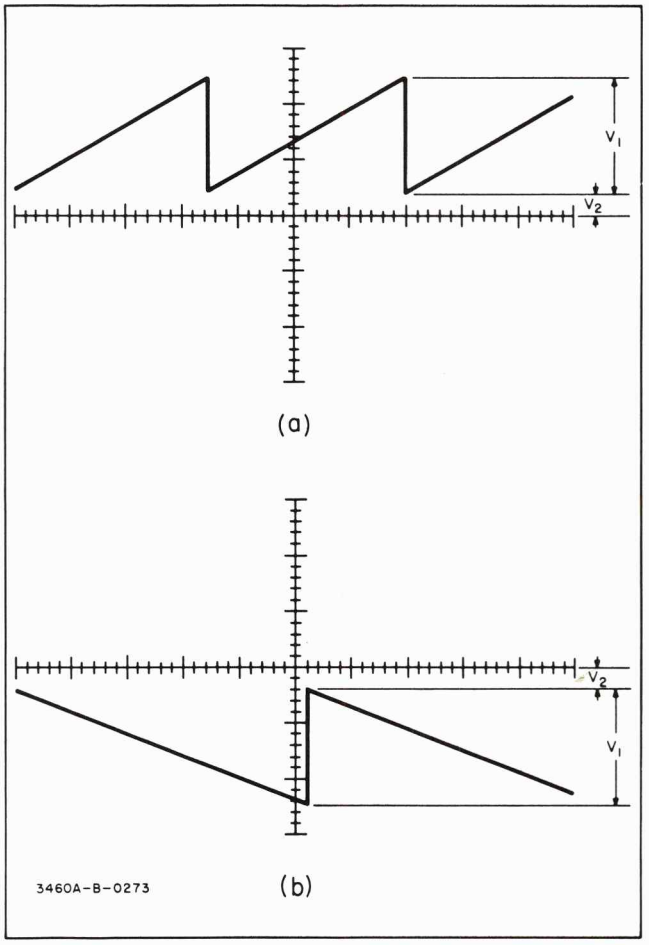


Figure 5-8. Level Set Adjustment Waveforms

h. Adjust +LEVEL SET (A2R5) until V_2 in Figure 5-8a is reduced to +25 mV ±10 mV.

NOTE

The voltage level of V_1 in Figure 5-8 should be 200 mV.

i. Reverse polarity to the Model 3460B INPUT, and adjust -LEVEL SET (A2R39) until V_2 in Figure 5-8b is reduced to -25 mV ±10 mV.

5-26. ZERO ADJUSTMENT (A1R9 and A4R15).

NOTE

Zero adjustment is performed with the bottom guard cover on.

a. An Oscilloscope (-hp- Model 140A) with a 10:1 Probe is required.

b. Connect oscilloscope between A16TP1 and chassis ground. Set INTERNAL TRIGGER LEVEL and SLOPE to +.

c. Set Model 3460B to LOCAL; RANGE to 10 volts; TRIGGERING RATE full clockwise; REAR-FRONT to FRONT; and short the INPUT with a shielded cable.

d. Adjust ZERO ADJ (A1R9) for minimum number of pulses per second as viewed on oscilloscope. Distance between pulses should be greater than 300 ms.

NOTE

Pulses are best observed on oscilloscope with a viewing hood. Set sweep to 100 ms/cm and vertical to 10 V/cm.

e. Depress 1 volt RANGE pushbutton, and replace the top guard cover.

f. Adjust ZERO (A4R15) through the top guard cover for minimum number of pulses per second as viewed on the oscilloscope. Distance between pulses should be greater than 100 ms.

g. Interaction exists between the 10 and 1 volt range zero adjustments; therefore, repeat steps d and f until proper results are obtained on both ranges.

5-27. V-TO-F CONVERTER CALIBRATION (A2R35 and A2R38).

NOTE

The V-to-F Converter calibration is performed with both top and bottom covers on.

a. A DC Standard (-hp- Model 740B) and an Electronic Counter (-hp- Model 5233L) are required. Use a 10-to-1 divider probe with counter (-hp- Model 10003B).

b. Connect dc standard output to Model 3460B INPUT for a + indication on the front panel display.

c. Connect electronic counter between A16TP1 and chassis ground with a 10-to-1 divider probe, and set counter to measure frequency.

d. Set Model 3460B to LOCAL; RANGE to 10 V, and rotate THRESHOLD ADJ (A16R88) full clockwise.

e. Adjust dc standard output for 0.00000 volts.

f. Rotate TRIGGERING RATE to HOLD position and depress TRIGGERING pushbutton.

NOTE

The Model 3460B digital display must indicate 0.0000.

g. Adjust dc standard output for 0.60000 volts.

h. Verify electronic counter indicates 60 kHz ±2 Hz. If not, adjust +CAL (A2R38) through guard cover for proper counter display.

i. Adjust dc standard output to voltages listed in Table 5-7, and verify counter display for each setting.

j. Adjust dc standard output for 0.0000 volts; reverse polarity to the Model 3460B INPUT, and depress TRIGGERING pushbutton.

Table 5-7. V-to-F Linearity Check

DC STANDARD OUTPUT	ELECTRONIC COUNTER DISPLAY (KHZ)
0.60000 V	60 kHz ±2 Hz
0.50000 V	50 kHz ±4 Hz
0.40000 V	40 kHz ±5 Hz
0.30000 V	30 kHz ±5 Hz
0.20000 V	20 kHz ±4 Hz
0.10000 V	10 kHz ±3 Hz

k. Adjust dc standard output for 0.60000 volts.

m. Verify electronic counter indicates 60 kHz ±2 Hz. If not, adjust -CAL (A2R35 through guard cover for proper counter display).

n. Repeat step i to verify V-to-F linearity with negative input.

5-28. THRESHOLD ADJUSTMENT (A16R88).

a. Leave dc standard and electronic counter connected as outlined in Paragraph 5-27.

b. Rotate THRESHOLD ADJ (A16R88) fully clockwise.

c. Set Model 3460B to LOCAL; RANGE to 10; TRIGGERING RATE to HOLD; and depress TRIGGERING pushbutton.

NOTE

The Model 3460B digital display must indicate 0.0000.

d. Set dc standard output to 0.55000 V.

e. Electronic counter should indicate frequency of 55 kHz.

f. Rotate THRESHOLD ADJ (A16R88) slowly in a counterclockwise direction until a click is audible within the Model 3460B.

NOTE

The click will come from the right rear corner of the Model 3460B. After the click, the counter will no longer indicate 55 kHz.

5-29. GATE LENGTH ADJUSTMENT (A17R30).

a. An Electronic Counter (-hp- Model 5233L) is required. Use a 10-to-1 divider probe with counter (-hp- Model 10003B).

b. Connect electronic counter between A17TP1 and chassis ground, and set controls as follows:

A SLOPE .....-
B SLOPE .....+
FUNCTION .....TIME INTERVAL A-B
TIME BASE ..... 1μ sec
Input Ranges X1
LEVEL 0

c. Set Model 3460B to LOCAL; RANGE to 10 V; TRIGGERING RATE full clockwise.

d. Connect Remote Control Cable Assembly (-hp- Model 11085A) to REMOTE CONTROL connector on rear panel, and ground pin 18 (wire-color code: Pin 18, wht/blu/gray; Pin 36, chassis ground, blk).

e. With no input to the Model 3460B, the electronic counter should display a period of 16.667 ms (±0.006 ms). If not, adjust GATE LENGTH (A17R30) for proper counter display.

f. Depress Model 3460B 1 volt RANGE pushbutton and observe electronic counter displays period of 100.000 ms (±0.07 ms).

g. Disconnect Remote Control Cable Assembly.

5-30. REFERENCE CALIBRATION (A19A1R8) (10 Volt Range).

a. An Oscilloscope (-hp- Model 140A) and the equipment described in Paragraph 5-7 are required.

b. Connect oscilloscope between A16TP1 and chassis ground.

c. Verify zero on the 10 volt range as outlined in Paragraph 5-23.

d. Connect Model 3460B as shown in Figure 5-1 and remove top guard cover.

e. Set Model 3460B to LOCAL; RANGE to 10 V; TRIGGERING RATE full clockwise; REAR-FRONT to FRONT.

f. Connect the high side of 3460B and dc standard to the 9 V tap on divider.

g. Adjust dc standard output for null indication on null meter.

h. Adjust REF CAL (A19A1R8) for 9.0000 V display on Model 3460B.

i. Verify distance between pulses on oscilloscope to be greater than 400 ms. If not, continue to adjust REF CAL (A19A1R8) for minimum number of pulses (null) and a 9.0000 V digital display.

NOTE

Pulses are best observed on oscilloscope with a viewing hood. Set sweep to 100 ms/cm and vertical to 10 V/cm.

j. Check to insure that slight movement of A19A1 circuit board does not affect Model 3460B front panel display. If variations occur, remove circuit board and inspect pins and connector socket. If necessary, pins may be cleaned with emory cloth.

5-31. 1, 100, and 1000 VOLT RANGE ADJUSTMENT (A36/A8R22; A43/A50R6; and A43/A50R9).

a. An Oscilloscope (-hp- Model 140A) and the equipment described in Paragraph 5-7 are required.

b. Connect the Model 3460B as shown in Figure 5-1. Set Model 3460B to LOCAL; RANGE to 1; TRIGGERING RATE full clockwise; and REAR-FRONT switch to FRONT.

c. Connect the high side of 3460B and dc standard to the 1 V tap on divider.

d. Adjust dc standard output for null indication on null meter.

NOTE

Before performing the next step, verify the proper location of the adjustment on the A36 Assembly (A8 in 1-2-2-4 Options).

e. Adjust 1 V RANGE ADJ (A36R22) for 1.00000 V display on Model 3460B.

NOTE

After adjusting the 1 V RANGE ADJ, it may be necessary to replace the top guard cover to obtain the proper display.

f. Connect oscilloscope between A16TP1 and chassis ground, and verify distance between pulses on oscilloscope to be greater than 100 ms. If not, continue to adjust 1 V RANGE ADJ (A36R22) for minimum number of pulses (null) and a 1.00000 V digital display.

NOTE

Pulses are best observed on oscilloscope with a viewing hood. Set sweep to 100 ms/cm and vertical to 10 V/cm.

g. Depress 100 V RANGE pushbutton, and connect the high side of 3460B and dc standard to the 90 V tap on divider.

h. Adjust dc standard output for null indication on null meter.

i. Adjust 100 V RANGE ADJ (A43R6) for 90.000 V display on Model 3460B.

j. Verify distance between pulses on oscilloscope to be greater than 400 ms. If not, continue to adjust 100 V RANGE ADJ (A43R6) for minimum number of pulses (null) and a 90.000 V digital display.

k. Depress 1000 V RANGE pushbutton and connect the high side of 3460B and dc standard to the 900 V tap on divider.

m. Adjust dc standard output for null indication on null meter.

n. Adjust 1000 V RANGE ADJ (A43R9) for 900.00 V display on Model 3460B.

p. Verify distance between pulses on oscilloscope to be greater than 400 ms. If not, continue to adjust 1000 V RANGE ADJ (A43R9) for minimum number of pulses (null) and a 900.00 V digital display.

5-32. D-TO-A CONVERTER ACCURACY AND LINEARITY CHECK.

NOTE

The following check is part of the Adjustment and Calibration Procedures and should be performed to verify proper operation of the D-to-A Resistor Assembly (A36 or A8) and the D-to-A Relay Assembly (A21).

CAUTION

DO NOT ATTEMPT TO ADJUST ANY RESISTORS ON THE D-TO-A RESISTOR ASSEMBLY (A36 OR A8) EXCEPT R22 AS OUTLINED IN PARAGRAPH 5-28. ALL OTHER ADJUSTMENTS ON THE D-TO-A RESISTOR ASSEMBLY ARE FACTORY ADJUSTMENTS ONLY AND ARE NOT REQUIRED FOR FIELD CALIBRATION. THE STABILITY OF THE RESISTOR ON THE D-TO-A RESISTOR ASSEMBLY IS SUCH THAT CALIBRATION IS NOT REQUIRED FOR A PERIOD OF ONE YEAR OR MORE. WHEN CALIBRATION IS REQUIRED AS DETERMINED BY THE PROCEDURES OUTLINED BELOW, REFER TO THE D-TO-A RESISTOR ASSEMBLY (A8 OR A36) EXCHANGE PROGRAM DESCRIBED IN SECTION VI, REPLACEABLE PARTS.

5-33. First and Second Digit Accuracy and Linearity Check.

NOTE

The Reference Calibration and the 1, 100 and 1000 Volt Range Adjustments outlined in Paragraphs 5-30 and 5-31 must be performed prior to this check.

a. The equipment described in Paragraph 5-7 is required.

b. Set Model 3460B controls as follows:

LOCAL-REMOTE TRIGGERING ... LOCAL
TRIGGERING RATE .....MAX. CW
RANGE .....10 Volt
REAR-FRONT ..... FRONT
LOW-to-GUARD shorting bar ..... Connected

c. Connect Model 3460B and dc standard to voltage tap on divider identified in Table 5-8.

d. Adjust dc standard for null indication on null meter for each voltage tap connection, and verify 3460B digital display specified in Table 5-8.

e. If the Model 3460B does not meet above specifications, perform the D-to-A Reed Relay Check outlined in Paragraph 5-67. If all the D-to-A reed relays are functioning properly and all other assemblies within the 3460B are functioning properly, replace the D-to-A Resistor Assembly with an exchange assembly described in Section VI, Replaceable Parts.

Table 5-8. First and Second Digit D-to-A Converter Check

VOLTAGE TAP ON DIVIDER	3460B DIGITAL DISPLAY	DISPLAY TOLERANCE
10 V	10.0000	±1 count
9 V	9.0000	±1 count
8 V	8.0000	±1 count
7 V	7.0000	±2 counts
6 V	6.0000	±2 counts
5 V	5.0000	±2 counts
4 V	4.0000	±2 counts
3 V	3.0000	±2 counts
2 V	2.0000	±1 count
1 V	1.0000	±1 count
short Model 3460B input	0.0000	±1 count

5-34. Third Digit Accuracy and Linearity Check.

a. Connect dc standard output directly to Model 3460B input, and adjust output to voltage identified in Table 5-9 (dc standard on 1 volt range).

Table 5-9. Third Digit D-to-A Converter Check

DC STANDARD OUTPUT	3460B DIGITAL DISPLAY	DISPLAY TOLERANCE
.00000	0.0000	±1 count
.10000	0.1000	±1 count
.20000	0.2000	±1 count
.30000	0.3000	±1 count
.40000	0.4000	±1 count
.50000	0.5000	±1 count
.60000	0.6000	±1 count
.70000	0.7000	±1 count
.80000	0.8000	±1 count
.90000	0.9000	±1 count

b. If the Model 3460B does not meet the above specifications, perform the D-to-A Reed Relay Check outlined in Paragraph 5-67. If all the D-to-A reed relays are functioning properly, and all other assemblies within the 3460B are functioning properly, replace the D-to-A Resistor Assembly with an exchange assembly described in Section VI, Replaceable Parts.

CAUTION

CLEAN RUBBER GLOVES SHOULD BE WORN WHEN WORKING WITH THE D-TO-A RESISTOR ASSEMBLY (A8 OR A36). OTHERWISE, CONTAMINATION OF COMPONENTS, CONNECTIONS OR INSULATORS WILL REDUCE PERFORMANCE.

5-35. SERVICING.

WARNING

AFTER REMOVING OR REPLACING CONTROL KNOBS, REFILL SET-SCREW HOLES WITH G.E. TRANSLUCENT SILICON RUBBER RTV-108 (HP PART NO. 0470-0304).

5-36. The Model 3460B contains extremely high impedance circuits. Therefore, certain areas within the instrument must be kept free from contamination to preserve accuracy and performance. Clean rubber gloves should be worn at all times when working in or around these areas. In addition, low content rosin core solder should be used for all repair work. These areas are:

a. Input Range and Sensitivity Selector Assembly (A43/A50)

b. Digital-to-Analog Resistor Assembly (A36/A8).

c. Voltage-to-Current Converter Assembly (A5) (particularly the input cable and input connection).

d. REAR-FRONT INPUT switch.

5-37. Position LOCAL-REMOTE TRIGGERING selector to LINE OFF and remove the Model 3460B top cover and the support board (MP44) holding the out-guard assemblies in place. Observe the CAUTIONS printed on the support board and top guard cover.

CAUTION

PROPER LENGTH SCREWS MUST BE USED FOR ALL COVERS TO PREVENT SHORTING OF GUARD TO CHASSIS. THE -HP- PART NO. FOR COVER SCREWS ARE AS FOLLOWS:

TOP AND BOTTOM COVERS
-HP- PART NO. 2370-0013
TOP AND BOTTOM GUARD COVERS
-HP- PART NO. 2370-0016

5-38. All Model 3460B assemblies may be removed individually except the A41 Assembly. The A14 Assembly must be removed before the A41 Assembly can be removed. When inserting an assembly, the component side faces the center of instrument.

5-39. ASSEMBLY NOT REPAIRABLE IN THE FIELD.

5-40. The following assembly within the 3460B is not repairable in the field. Refer to Adjustment and Calibration Procedure in this section to verify proper operation of assembly.

1-2-4-8 BCD ..... Assembly A36
1-2-2-4 BCD ..... Assembly A8

5-41. REED RELAY REPLACEMENT.

5-42. When replacing a faulty reed relay in the D-to-A Relay Assembly (A21), perform the following procedures.

a. Refer to Figure 5-9 for reed relay contact identification.

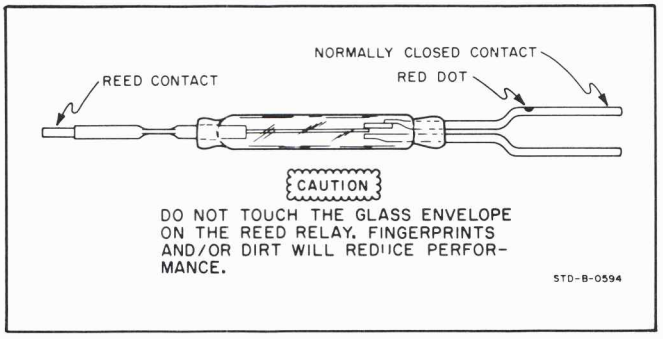


Figure 5-9. Reed Relay Identification

b. Position the Model 3460B REMOTE-LOCAL TRIGGERING selector to LINE OFF.

c. Using a low-heat soldering iron, disconnect the normally closed and open contacts by applying heat and cutting between the relay contacts and the stand-off terminals with a razor blade or knife.

NOTE

Observe the proper connection of the normally closed and open contacts. K1 and K2 differ from K3 through K12.

d. Unsolder the "reed contact" and remove the relay from the double contact side.

CAUTION

DO NOT TOUCH THE GLASS ENVELOPE ON THE REED RELAY. FINGERPRINTS AND/OR DIRT WILL REDUCE PERFORMANCE.

e. Insert the replacement reed relay from the double contact side.

CAUTION

WHEN SOLDERING THE REPLACEMENT REED RELAY, USE A HEAT SINK (A PAIR OF PLIERS) ON EACH CONTACT, AND DO NOT APPLY PRESSURE TO ANY CONTACT WHEN SOLDERING. OTHERWISE, DAMAGE TO THE REED RELAY WILL RESULT.

f. Solder the "reed contact" on the replacement relay first with the other two contacts making contact with the appropriate standoff terminals.

g. Solder the normally closed and open contacts to appropriate standoff terminals.

5-43. AIR FILTER

5-44. The Model 3460B contains a fan-air filter combination for cooling. The filter must be kept clean for the fan to be effective. Overheating can cause serious inaccuracies and possible damage to components. The air filter (-hp- Part No. 3150-0040) is located on the rear panel. Inspect the air filter at regular intervals. Clean the filter as required with a warm-mild detergent solution and immediately dry it. An air hose may also be used to clean the air filter.

5-45. ETCHED CIRCUIT BOARDS.

5-46. The standard Model 3460B contains seventeen etched circuit boards. Use caution when removing them to avoid damaging mounted components. An assembly -hp- part number is silk screened on the circuit board to identify it.The metal D-to-A Resistor Assembly (A36/A8) is identified by part number on an adhesive nameplate which is attached to the assembly. Refer to Section VI for parts replacement information.

5-47. The etched circuit board is a plated-through type. The electrical connection between sides of the board is made by a layer of metal plated through the component holes. When working on these boards, observe the following general rules.

a. Use a low-heat (37 to 45 watt) small-tip soldering iron, and a small diameter rosin core solder.

b. Circuit components can be removed by placing the soldering iron on the component lead on either side of the board, and pulling up on lead. If a component is obviously damaged, clip leads as close to component as possible and then remove. Excess heat can cause the circuit and board to separate, or cause damage to the component.

c. Component lead holes should be cleaned with a toothpick or other similar device before inserting new lead.

d. To replace components, shape new leads and insert them in holes. Reheat with iron and add solder as required to insure a good electrical connection.

e. Clean excess flux and/or solder from the connection and adjoining area.

5-48. To avoid surface contamination on all etched circuit boards except the A5 and A17 Assemblies, perform the following:

a. Clean with a solution of "Finish Dishwashing Detergent" and warm water.

b. Rinse thoroughly with clean water and immediately dry.

CAUTION

WHEN USING ANY ANTI-HUMIDITY SPRAY, THE ETCHED CIRCUIT BOARD PINS AND/OR EXTERNAL CONNECTIONS MUST BE COVERED WITH TAPE OR EQUIVALENT MATERIAL. OTHERWISE, AN INADEQUATE ELECTRICAL CONNECTION TO THE APPROPRIATE CONNECTOR WILL RESULT.

c. When completely dry and properly masked, spray lightly with "General Electric Dry Film 88" anti-humidity spray.

5-49. The A17 Assembly may be cleaned as outlined in Paragraph 5-48 by removing the reed relay, K1, prior to step a, and replacing it prior to step c.

5-50. The A5 Assembly may be cleaned as outlined in Paragraph 5-48 except in the area of the Photochopper Assembly A5A1. Solder connections and teflon insulators on Photochopper Assembly may be cleaned, if necessary, with a fine wire brush, and lightly spray with "Dry Film 88" anti-humidity spray.

CAUTION

WATER, COMMERCIAL CLEANERS, OR DETERGENTS WILL CAUSE PERMANENT DAMAGE TO PHOTOCHOPPER ASSEMBLY, A5A1. USE LOW CONTENT ROSIN CORE SOLDER FOR ALL REPAIR WORK ON PHOTOCHOPPER, AND AVOID GETTING SOLDER OR ROSIN ACROSS THE TEFLON INSULATORS.

5-51. The Metal D-to-A Resistor Assembly (A36 or A8) may be cleaned as outlined in Paragraph 5-48.

CAUTION

DO NOT DISTURB THE SETTINGS ON THE FACTORY ADJUSTED RESISTORS R15, R23-R30. REFER TO THE CAUTION UNDER PARAGRAPH 5-32.

5-52. The Metal Input Range and Sensitivity Selector (A43) may be cleaned as outlined in Paragraph 5-48 except in the area of reed relays. Water, commercial cleaners or detergents will cause permanent damage to reed relays. Solder connections and teflon insulators for reed relays may be cleaned with a fine wire brush. Solder connections and teflon insulators for reed relays on the D-to-A Relay Assembly (A21) may also be cleaned with fine wire brush and sprayed lightly with "Dry Film 88."

5-53. READOUT BLOCK ASSEMBLY REPLACEMENT.

5-54. When replacing the readout block assembly on a Reversible Counting Decade, the following procedure should be followed:

CAUTION

THE COMPONENT LEAD HOLES ON THE CIRCUIT BOARD HAVE PLATED WALLS TO ENSURE GOOD ELECTRICAL CONTACT BETWEEN CONDUCTORS ON THE OPPOSITE SIDE OF THE BOARD. TO PREVENT DAMAGE TO THIS PLATING AND TO THE REPLACEMENT BLOCK ASSEMBLY, APPLY HEAT SPARINGLY AND WORK CAREFULLY. A 37 TO 45 WATT SOLDERING IRON (IDLING TEMPERATURE ABOUT 800°F) IS RECOMMENDED FOR SERVICING THIS CIRCUIT BOARD.

a. Remove four screws holding the readout block assembly to the board.

b. Remove two screws holding the cover plate on the block and lift off the cover plate. Unsolder the two wires which are connected between photoconductor plate and board. Cut the 16 neon lamp wires.

c. Unsolder wires underneath block assembly. Also note position and color of wires as the replacement assembly will have these wires.

d. Remove the two screws holding the digital display tube socket to the readout block assembly and unsolder wires connected to the socket. Also, note the position and color of wires for the replacement assembly.

e. Remove the block assembly and all clipped wires from board and clean holes of solder by heating hole with a clean tinned iron and inserting a toothpick or wooden splinter.

f. Before mounting new block assembly, bend and position wires to align with holes on board. The 90° bend on a wire should be 1/16" or more from neon block.

g. A stress relief wire alongside the neon block and board is recommended when pulling wires through from the bottom of the board. A 4" length of 0.051 piano wire or 16 gauge bare wire will help prevent the 16 neon leads from being pulled too close to the board.

h. Remove stress relief wire.

i. Solder wires underneath block assembly to same position as noted in step c, and solder wires to digital display tube socket as noted in step d.

j. Secure the digital display tube socket and block assembly on board, using the screws removed in steps a and d.

k. Solder wires and slip excess lead length off.

m. Remove cover plate on block assembly and solder two leads back on to photoconductor plate. Replace cover plate being careful to keep gaskets under photoconductor plate in place.

CAUTION

WHEN REPLACING ONLY THE PHOTOCONDUCTOR MATRIX (V1), DO NOT CONTAMINATE THE CONDUCTIVE MATERIAL ON THE PHOTOCONDUCTOR MATRIX. IT IS ALSO RECOMMENDED TO REPLACE THE RESISTIVE NETWORK WHEN REPLACING V1.

5-55. NEON OSCILLATOR SUBASSEMBLY REPLACEMENT.

5-56. When replacing the neon oscillator subassembly on the Photochopper Assembly, A5A1, perform the following procedures:

CAUTION

CLEAN RUBBER GLOVES SHOULD BE WORN AT ALL TIMES WHEN WORKING ON THE A5 ASSEMBLY. IN ADDITION, LOW CONTENT ROSIN CORE SOLDER SHOULD BE USED FOR ALL REPAIR WORK. OTHERWISE, CONTAMINATION OF COMPONENTS, CONNECTIONS OR PC BOARD WILL REDUCE PERFORMANCE.

a. Remove the A5 assembly.

b. Disconnect the three leads from the neon subassembly at the A5 assembly. Note location for reconnecting the leads of the replacement subassembly.

c. Remove and discard the defective subassembly. Note orientation of the three wire grommet.

d. Mount the replacement subassembly (as noted in step c) and reconnect the leads disconnected in step b.

e. Replace A5 assembly and perform the Adjustment and Calibration procedure outlined in Paragraph 5-19.

5-57. INPUT BINDING POSTS.

5-58. The installation of a front panel binding post is illustrated in Figure 5-10A and B.

CAUTION

DO NOT CONTAMINATE INSULATORS OR BUSHINGS ON THE BINDING POST WHEN REMOVING OR INSTALLING IT, AND VERIFY PROPER INSERTION OF THE FLARED TEFLON. OTHERWISE, THE INPUT RESISTANCE WILL BE REDUCED.

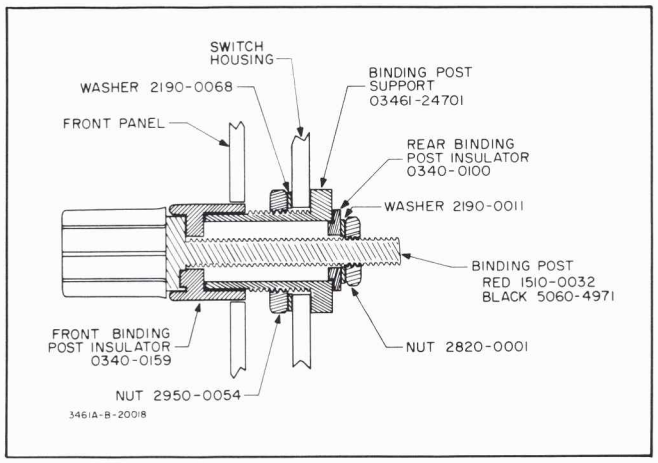


Figure 5-10A

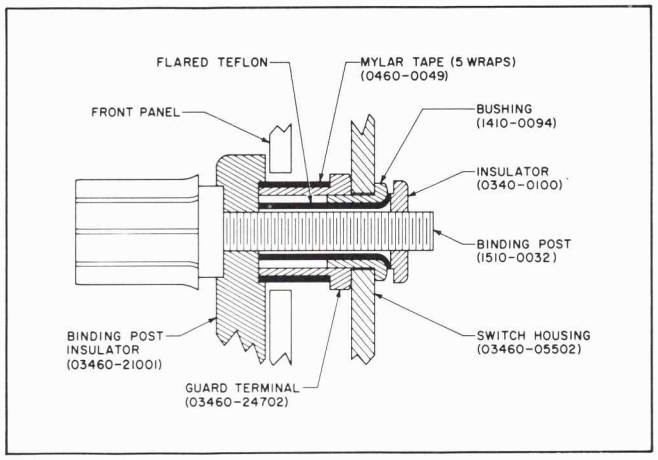


Figure 5-10B

5-59. REPLACEMENT OF MATCHED ASSEMBLIES.

5-60. Two assemblies within the 3460B are matched:

a. Plus and Minus 25 Volt Power Supply (A4).

b. Voltage-to-Current Converter (A5).

When replacing or completing repairs on either one or both of the above assemblies, perform the following procedure:

a. A DC Voltmeter (-hp- Model 412A) is required.

b. Position Model 3460B LOCAL-REMOTE TRIGGERING selector to LINE OFF.

CAUTION

CLEAN RUBBER GLOVES SHOULD BE WORN AT ALL TIMES WHEN WORKING ON THE A5 ASSEMBLY. OTHERWISE, CONTAMINATION OF COMPONENTS, CONNECTIONS OR PC BOARD WILL REDUCE PERFORMANCE.

c. Disconnect the input cable to the A5 Assembly with a pair of clean pliers and place the input cable in an area free from any electrical connection and contamination.

d. Mount the A4 and A5 Assemblies on 15 pin printed circuit board extenders.

e. Connect A5TP3 and A5TP4 to photochopper block (common point ▽) with two jumper leads.

f. Set Model 3460B controls as follows:

LOCAL-REMOTE TRIGGERING ... LOCAL
TRIGGERING RATE .....MAX. CW
RANGE .....10 Volt
REAR-FRONT ..... FRONT
LOW-to-GUARD shorting bar ..... Connected

NOTE

The Model 3460B will indicate overload.

g. Measure voltage between pin 15 on A5 and the chassis of the A4 and A5 Assemblies (common point ▽).

h. Adjust COARSE ZERO (A4R11) for a dc voltmeter indication as near to zero volts as possible.

i. Position Model 3460B LOCAL-REMOTE TRIGGERING selector to LINE OFF.

j. Insert the A4 Assembly into proper connector (J4) within the instrument, and remove the jumper leads from the A5 Assembly.

k. Connect the dc voltmeter between TP1 and TP2 on A5 assembly (low side to TP1).

m. Connect jumper lead between modulator side of A5C10 and the photochopper block (common point ▽).

n. Position Model 3460B LOCAL-REMOTE TRIGGERING selector to LOCAL.

o. Adjust LEVEL SET (A5R30) for zero volts (±100 mV).

p. Replace A5 Assembly and perform the Adjustment and Calibration Procedure outlined in Paragraph 5-19.

5-61. TROUBLESHOOTING

5-62. Troubleshooting information pertinent to the Model 3460B Digital Voltmeter is contained in this portion of Section V. Troubleshooting should be undertaken only after it has been established that the difficulty cannot be eliminated by the Adjustment and Calibration Procedures, Paragraph 5-19. An investigation should also be made to insure that the trouble is not a result of conditions external to the Model 3460B. A visual check of the Model 3460B should be made for possible burned or loose components, loose connections, or any other condition which might suggest a source of trouble. Check to insure that all printed circuit boards are properly inserted in the instrument.

5-63. The following general procedure is recommended when troubleshooting the Model 3460B.

a. First, obtain as much information as possible concerning the malfunction from the front panel of the instrument, i.e. is the malfunction restricted to any particular range setting(s); any particular digit or polarity, is the digital display linear, etc.

b. Second, refer to Table 5-10 to further isolate the problem to a particular functional area(s).

c. The final step in the isolation process is to perform detailed troubleshooting on the possible problem area(s) identified in Table 5-10.

NOTE

In addition to Table 5-10, Paragraph 5-64 thru 5-87 outline checks that may be performed to isolate the trouble or verify the operation of an assembly.

5-64. V-TO-F CONVERTER CHECK

NOTE

Calibration of the V-to-F Converter as outlined in Paragraph 5-27 to the limits specified in Table 5-7 verifies proper operation of the V-to-F Converter with the exception of A43K6 and K8. Refer to Detailed Block Diagram, Figure 7-2, for assemblies within the V-to-F Converter.

a. To conduct a rear panel V-to-F check, set Model 3460B LOCAL-REMOTE Triggering Selector to LOCAL; RANGE to 10 V; TRIGGERING RATE full clockwise; REAR-FRONT to FRONT; and short the INPUT.

b. Set V/F CHECK switch on rear panel to + position. Model 3460B front panel display should indicate +10.0000 V (±1 count in fourth digit).

c. Set V/F CHECK switch to - position. Model 3460B front panel display should indicate -10.0000 V (±1 count in fourth digit).

d. Return V/F CHECK switch to center position.

e. If the above checks did not meet the specified limits, recalibrate the V-to-F Converter as outlined in Paragraph 5-27.

f. If recalibration is possible, repeat rear panel V-to-F Check. If the proper results are still not obtained, check Reference Power Supply (A19); D/A Resistor and Relay Assemblies A36/A8 and 21. Refer to Paragraph 5-32.

g. If the V-to-F Converter cannot be calibrated properly, check the Voltage-to-Current Converter (A5) as outlined in Paragraph 5-65.

h. If the Voltage-to-Current Converter appears to be functioning properly, check the Integrator (A1), the Precision Current Pulse Generator (A2) and the +17.5 V Power Supply (A3).

5-65. VOLTAGE-TO-CURRENT CONVERTER CHECK.

a. Set Model 3460B LOCAL-REMOTE Triggering Selector to LOCAL; RANGE to 10 V; TRIGGERING RATE to HOLD; REAR-FRONT to FRONT.

b. Connect a dc standard output to Model 3460B INPUT.

c. Connect a short test lead from LOW INPUT to chassis containing the A1, A2 and A3 Assemblies (common point ▽2).

d. Adjust dc standard for 5.000 V output.

e. Depress TRIGGERING pushbutton on Model 3460B front panel.

NOTE

The 3460B display will not indicate 5.0000 V.

f. Connect a dc voltmeter across LOW INPUT and the chassis containing the A4 and A5 Assemblies (common point ▽1).

g. The dc voltmeter should indicate approximately 0.05 V. If not, perform the input attenuator check, and conduct a thorough investigation of the Voltage-to Current Converter Assembly, A5, and the sensitivity selector reed relays on the Input Range and Sensitivity Selector (A43).

h. Further troubleshooting information for the V-C Converter can be found on Page 7-6.

Table 5-10. Troubleshooting

FRONT PANEL SYMPTOM	POSSIBLE PROBLEM AREA	POSSIBLE COMPONENT MALFUNCTION
MANUAL MALFUNCTION:		
1 V only	Auto Range Selector (A41) Input Range Selector (A43)	A41Q24 A43K6
100 V only	Auto Range Selector (A41) Input Range Selector (A43)	A41Q18 A43K4
1000 V only	Auto Range Selector (A41) Input Range Selector (A43)	A41Q20 A43K5
1 V and 10 V only	Auto Range Selector (A41) Input Range Selector (A43)	A41Q10, Q14 A43K1
1 V and 100 V only	Auto Range Selector (A41) Input Range Selector (A43)	A41Q8, Q17 A43K2
10 V and 1000 V only	Auto Range Selector (A41) Input Range Selector (A43)	A41Q19 A43K3
100 V and 1000 V only	Auto Range Selector (A41)	A41Q11
1V, 10 V, 100 V and 1000 V	Timing and Control Assembly (A14) Auto Range Selector (A41) Input Range Selector (A43)	A14Q18, Q19 A41Q21, Q22, Q23 A43K7
AUTO MALFUNCTION:		
In automatic ranging, with no input the instrument after power is applied sticks on:		
10 V thru 1000 V	Auto Range Selector (A41) Input Range Selector (A43)	A41Q25 A43K8
1000 V range	Auto Range Selector Polarity Control (A16) Timing and Control (A14) Input Range Selector (A43)	A41Q3 A16Q19, Q20, Q21 A14Q4, Q5, Q16, Q17 A43K3, K5, K7, K8
100 V range	Input Range Selector (A43)	A43K2, K4, K7, K8
10 V range	Input Range Selector (A43)	A43K1, K3, K7, K8
Functions properly in manual, but fails to uprange.	N_1 and N_2 RCD (A13 or A35)	Overload Signal Amplifier
	Timing and Control (A14)	A14CR51, CR53
GENERAL:		
With overload applied to input, overload lamp remains off; instrument will not uprange.	N_1 and N_2 RCD (A13 or A35) Front Panel	Overload Signal Amplifier Check overload indicator
Polarity indicator lamp will not function either + or	Counter Driver Assembly (A16)	Q11 thru Q14
	All Counting Units	Zero Detect Lines
	Auto Range Selector (A41)	Photoconductor matrix, V1 Display tube, DS2

Table 5-10 Troubleshooting (Cont'd)

FRONT PANEL SYMPTOM	POSSIBLE PROBLEM AREA	POSSIBLE COMPONENT MALFUNCTION
GENERAL (Cont'd):		
Faulty display. (Numbers are fuzzy with green glow, and sections of numbers are not appearing.)	Respective Counting Unit(s)	Digital Display Tube
Faulty display. (More than one digit appearing.)	Respective Counting Units(s)	Photoconductor matrix, V1
Unstable display; relay chatter	D/A Relay Assembly (A21)	Reed Relays
	N_1, N_2, N_3, N_4 Counting Unit(s)	Storage Binaries
Front panel display proportionally low on all ranges	Reference Power Supply (A19)	Adjust Reference Supply (Paragraph 5-27)
Front panel display error not proportional regardless of range or input.	D/A Relay Assembly (A21)	Reed Relays (See Paragraph 5-32)
	Sample Period Generator	A17Q3
TRIGGERING RATE control on front panel has no effect on actual trigger rate.	Timing and Control Assembly (A14)	A14Q15, S3, R1
Instrument triggers manually, but not automatically.	Timing and Control Assembly (A14)	A14CR38, A14Q23, A14Q15, S3, R1
Functions properly only with:		
+ input	Precision Current Pulse Generator (A2)	Check A2Q7 thru Q12
	D/A Relay Assembly (A21)	Reed Relays A21K13 or K14 (See Paragraph 5-32)
- input	Precision Current Pulse Generator (A2)	Check A2Q1 thru Q6
	D/A Relay Assembly (A21)	Reed Relays A21K13 or K14
Front panel polarity remains fixed either + or -.	D/A Relay Assembly (A21)	Reed Relays, A21K13 or K14 (See Paragraph 5-32)

5-66. INPUT ATTENUATOR CHECK

NOTE

The purpose of this check is to verify proper operation of range selector reed relays on the Input Range and Sensitivity Selector (A43). Refer to Table 4-2 for proper attenuation during both first and second sample periods.

a. Set 3460B to LOCAL; RANGE to 10 V; REAR-FRONT to FRONT; TRIGGERING RATE full clockwise.

b. Connect a dc standard to Model 3460B INPUT, and adjust output for 10 V.

CAUTION

DO NOT CONTAMINATE THE INPUT CABLE OR INPUT CONNECTION TO THE A5 ASSEMBLY. CONTAMINATION WILL REDUCE PERFORMANCE.

c. Connect a dc voltmeter between LOW INPUT binding post and the conductor on the Voltage-to-Current Converter (A5) input cable.

NOTE

The dc voltmeter used must have an input impedance of greater than 200 megohms.

d. Depress each RANGE pushbutton identified in Table 5-11 and verify dc voltmeter indicates voltage listed.

NOTE

The 3460B DISPLAY will not indicate 10.0000 V.

Table 5-11. Input Attenuator Check

RANGE	DC VOLTMETER INDICATIONS
10 V	10 V
100 V	1.0 V
1000 V	0.1 V

e. With Model 3460B on the 1000 V RANGE, position V/F CHECK switch on the rear panel to +, and verify that the dc voltmeter indicates approximately 0.001 volts.

f. Depress the 100 V RANGE pushbutton and verify that the dc voltmeter indicates approximately 0.01 volts.

g. Return V/F CHECK switch to center position and disconnect the dc standard and dc voltmeter.

5-67. D-TO-A REED RELAY CHECK.

CAUTION

VOLTMETER CONNECTIONS TO REED RELAYS WITHIN THE A21 ASSEMBLY MUST NOT TOUCH SHEET METAL (GUARD ⑷) IN OR NEAR THE A21 ASSEMBLY; OTHERWISE, DAMAGE TO D-TO-A REED RELAYS WILL RESULT.

5-68. Faulty Relay Identification.

5-69. Reference Supply and Polarity Relays K13 and K14.

a. Connect floating dc voltmeter from A21K14 reed contact (see Figure 5-9) to K13 reed contact (low side to K13).

b. Select local trigger and HOLD.

c. Set V/F CHECK switch on rear panel to + position.

d. Measure +13.96 V on dc voltmeter (13.30 V Option 001, 003, 005 or 007).

e. Set V/F CHECK switch to - position.

f. Measure -13.96 V on dc voltmeter (13.30 V Option 001, 003, 005 or 007).

This check indicates that the reference power supply and polarity relays are operating.

5-70. D-to-A Feedback Relays.

Symptom: Instrument reads overload or counts with zero input.

a. Short input; select 10 V range and max trigger rate.

b. Select V/F CHECK with rear panel switch. (Selects 1st sample only, N_5 and N_6 zero, N_1 thru N_4 reset after each sample.)

c. Connect jumper wire between ⑵ (chassis containing A1, A2, and A3 assemblies) and ⑶ (LO input terminal).

d. If the D-to-A is the problem area, the 3460 readout will go to 00000.

e. Select trigger HOLD.

f. Return V/F CHECK switch to center position.

g. Remove jumper between ⑵ and ⑶.

h. Measure D-to-A voltage between ⑵ and ⑶. (D-to-A output impedance is approximately 10 kilohms.)

i. If a relay is in the wrong position, the voltage measured in h, indicates the faulty relay.

K1	4 V	K5	0.8 V	K9	0.08 V
K2	4 V	K6	0.4 V	K10	0.04 V
K3	2 V	K7	0.2 V	K11	0.02 V
K4	1 V	K8	0.1 V	K12	0.01 V

(for 1248 code)

Example: (1248 code)
D-to-A Voltage 0.08 V
Inoperative relay K9

K9 may be inoperative because:

1) The reed is stuck.
2) Coil L9 is open.
3) K9 drive circuit has failed.

5-71. Check for Weak Relays.

Symptom: Intermittent overload or counting.

a. Disconnect from J12 pin 7 the WHT/BLK/VIO wire that goes to A21L1 thru L14. This is the -17 V power supply line to A21.

b. Connect a dc variable power supply (-hp- Model 6220B) between chassis ground and the WHT/BLK/VIO wire.

c. Decrease the 6220B supply voltage to -16 volts.

d. Select local trigger, max count rate, and 10 V range.

e. Connect dc standard (-hp- Model 740B to 3460 input).

f. Adjust dc standard output to get 0.01XX, 0.02XX, ... 0.09XX readout on 3460.

g. Adjust dc standard output to get 0.10XX, 0.20XX, ... 0.90XX readout on 3460.

h. Adjust dc standard output to get 1.00XX, 2.00XX, ... 9.00XX, 10.00XX, 11.00XX readout on 3460.

i. If the 3460 displays overload or random counting during steps f, g, or h, return to check 2 step i to determine which relay is at fault.

j. Decrease 6220B supply voltage to -14 volts and repeat steps d through i.

k. Check operation of polarity relays K13 and K14 at this lower drive voltage by reversing polarity to 3460 input.

Checking reed relay operation at -14 V coil supply voltage increases the failure possibility of a weak contact closure.

5-72. Check For Resistive Relays.

NOTE

The purpose of this check is to verify proper operation of reed relays in the D-to-A Relay Assembly (A21) by measuring voltage drop across each relay in both the energized and de-energized condition. Refer to the inside cover for proper location of reed relays.

a. A DC Standard (-hp- Model 740B) and a DC Null Voltmeter (-hp- Model 419A) are required.

b. Position 3460B REMOTE-LOCAL TRIGGERING selector to LINE OFF, and remove the bottom cover and the bottom guard cover from the instrument, and position the instrument on its side.

5-73. Polarity Reed Relay Check (K13, K14).

CAUTION

VOLTMETER CONNECTIONS TO REED RELAYS WITHIN THE A21 ASSEMBLY MUST NOT TOUCH SHEET METAL (GUARD ▽4) IN OR NEAR THE A21 ASSEMBLY; OTHERWISE, DAMAGE TO D-TO-A REED RELAYS WILL RESULT.

a. Connect the low side of the dc null voltmeter to the "reed contact" (see Figure 5-9) on K13 relay on the top side of A21 Assembly.

b. Set Model 3460B controls as follows:

LOCAL-REMOTE TRIGGERING . . . LOCAL
TRIGGERING RATE . . . . . .MAX. CW
RANGE . . . . . .10 Volt
REAR-FRONT . . . . . FRONT
LOW-to-GUARD shorting bar . . . . . Connected

c. Connect dc standard to 3460B INPUT, and adjust output for +6.5500 volts.

d. Measure voltage drop across K13 by connecting the high side of the dc null voltmeter to the normally open contact of K13. The voltage measured must be less than 250 μ volts.

e. Connect dc standard to 3460B INPUT for -6.5500 V output, and connect the high side of dc null voltmeter to normally closed contact of K13. The voltage measured must be less than 250 μ volts.

f. Connect the low side of the dc null voltmeter to the "reed contact" of the K14 relay on the top side of A21 Assembly.

g. With dc standard at -6.5500 volts, measure voltage drop across K14 by connecting dc null voltmeter to normally open contact of K14 relay. The voltage measured must be less than 250 μ volts.

h. Connect dc standard to 3460B INPUT for a +6.5500 V output, and connect dc null voltmeter to normally closed contact of K14. The voltage measured must be less than 250 μ volts.

j. If the voltage measured is greater than 250 μ volts, replace the respective polarity relay as outlined in this section under servicing (Paragraph 5-35).

5-74. 1-2-4-8 Reed Relay Check (K1 thru K12).

NOTE

For 1-2-2-4 Reed Relay Check, refer to Paragraph 5-75.

a. Refer to Figure 5-9 for reed relay contact identification.

b. Set Model 3460B controls as follows:

LOCAL-REMOTE TRIGGERING ... LOCAL
TRIGGERING RATE .....MAX. CW
RANGE .....10 Volt
REAR-FRONT ..... FRONT
LOW-to-GUARD shorting bar ..... Connected

c. Observe the caution under Paragraph 5-73 and connect the low side of dc null voltmeter to the "reed contact" of the K13 or K14 relay on the top side of A21 Assembly as identified in Table 5-12.

d. Connect dc standard to 3460B front INPUT and adjust output for 3460B display identified in Table 5-12.

e. Measure voltage drop across the reed relay identified in Table 5-12 for each 3460B display by connecting the high side of dc null voltmeter to the respective "reed contact" on the bottom side of A21 Assembly. The voltage measured must be less than specified in Table 5-12.

f. If voltage measured across any one relay is greater than specified in Table 5-12, replace the relay as outlined in this section under servicing (Paragraph 5-35).

NOTE

If all reed relays check out good, refer to Paragraph 5-33, step e.

5-75. 1-2-2-4 Reed Relay Check (K1 thru K12).

a. Refer to Figure 5-9 for reed relay contact identification.

b. Set Model 3460B controls as follows:

LOCAL-REMOTE TRIGGERING .... LOCAL
TRIGGERING RATE .....MAX. CW
RANGE .....10 Volt
REAR-FRONT ..... FRONT
LOW-to-GUARD shorting bar ..... Connected

c. Observe the caution under Paragraph 5-73 and connect the low side of dc null voltmeter to the "reed contact" of the K13 or K14 relay on the top side of A21 Assembly as identified in Table 5-13.

d. Connect dc standard to 3460B front INPUT and adjust output for 3460B display identified in Table 5-13.

e. Measure voltage drop across the reed relay identified in Table 5-13 for each 3460B display by connecting the high side of dc null voltmeter to the respective "reed contact" on the bottom side of A21 Assembly. The voltage measured must be less than specified in Table 5-13.

f. If voltage measured across any one relay is greater than specified in Table 5-13, replace the relay as outlined in this section under servicing (Paragraph 5-35).

NOTE

If all reed relays check out good, refer to Paragraph 5-33, step e.

5-76. TIMING AND CONTROL CHECK.

a. Set Model 3460B to LOCAL; RANGE to 10 V; REAR-FRONT to FRONT; TRIGGERING RATE full clockwise.

b. Connect a dc standard output to Model 3460B INPUT, and adjust for 0.0050 V.

c. Connect oscilloscope to the test points identified, and observe waveforms illustrated in Figure 5-11.

NOTE

Externally trigger oscilloscope to A14TP1. Set TRIGGER LEVEL and SLOPE to +, and center oscilloscope trace on graticule.

5-77. SAMPLE PERIOD GENERATOR CHECK.

a. To check the 1/60 sec (16.67 ms) sample period, set Model 3460B to LOCAL; RANGE to 10 V; REAR-FRONT to FRONT; and TRIGGERING RATE fully clockwise.

b. Connect Remote Control Cable Assembly (-hp-Model 11085A) to REMOTE CONTROL connector on rear panel, and connect Pin 35 to Pin 36, chassis ground (wire color code: Pin 35, wht/blu/vio, pin 36, blk).

c. Connect dc standard output to Model 3460B INPUT and adjust for 0.0050 V output.

d. Connect oscilloscope to A17TP1. Externally trigger the oscilloscope with connection to A14TP1. Set TRIGGER LEVEL and SLOPE to +.

e. Figure 5-12a illustrates the waveform which should appear.

Table 5-12. 1-2-4-8 Reed Relay Check

LOW SIDE VOLTMETER CONNECTION	3460B DISPLAY	REED RELAY	MAX. VOLTAGE DROP
K13	±4.0010	K2	200 microvolts
K13	±8.0010	K1	100 microvolts
K13	±2.0010	K3	100 microvolts
K13	±1.0010	K4	100 microvolts
K13	±0.8010	K5	1000 microvolts
K13	±0.7010	K6	500 microvolts
K13	±0.7010	K7	300 microvolts
K13	±0.7010	K8	100 microvolts
K13	±0.0810	K9	1000 microvolts
K13	±0.0710	K10	500 microvolts
K13	±0.0710	K11	300 microvolts
K13	±0.0710	K12	100 microvolts
K14	±3.0010	K2	100 microvolts
K14	±7.0010	K1	300 microvolts
K14	±9.0010	K3	200 microvolts
K14	±8.0010	K4	100 microvolts
K14	±9.0010	K5	700 microvolts
K14	±9.0010	K6	350 microvolts
K14	±9.0010	K7	200 microvolts
K14	±9.0010	K8	100 microvolts
K14	±9.0010	K9	700 microvolts
K14	±9.0010	K10	350 microvolts
K14	±9.0010	K11	200 microvolts
K14	±9.0010	K12	100 microvolts

NOTE

The last two digits of the 3460B display do not have to indicate "10" but should indicate some number between "01" and "99" in order to keep the second, third or fourth digit display on the proper numeral. Refer to Tables 5-15 and 5-16 for reed relay logic.

Table 5-13. 1-2-2-4 Reed Relay Check

LOW SIDE VOLTMETER CONNECTION	3460B DISPLAY	REED RELAY	MAX. VOLTAGE DROP
K13	±6.0010	K2	100 microvolts
K13	±4.0010	K1	200 microvolts
K13	±2.0010	K3	100 microvolts
K13	±5.0010	K4	100 microvolts
K13	±0.9010	K5	500 microvolts
K13	±0.9010	K6	300 microvolts
K13	±0.9010	K7	300 microvolts
K13	±0.9010	K8	100 microvolts
K13	±0.0910	K9	500 microvolts
K13	±0.0910	K10	300 microvolts
K13	±0.0910	K11	300 microvolts
K13	±0.0910	K12	100 microvolts
K14	±5.0010	K2	200 microvolts
K14	±7.0010	K1	200 microvolts
K14	±9.0010	K3	200 microvolts
K14	±8.0010	K4	100 microvolts
K14	±9.0010	K5	400 microvolts
K14	±9.0010	K6	200 microvolts
K14	±9.0010	K7	200 microvolts
K14	±9.0010	K8	100 microvolts
K14	±9.0010	K9	400 microvolts
K14	±9.0010	K10	200 microvolts
K14	±9.0010	K11	200 microvolts
K14	±9.0010	K12	100 microvolts

NOTE

The last two digits of the 3460B display do not have to indicate "10" but should indicate some number between "01" and "99" in order to keep the second, third or fourth digit display on the proper numeral. Refer to Tables 5-15 and 5-16 for reed relay logic.

f. Remove the ground from pin 35 on REMOTE CONTROL connector.

g. Figure 5-12b illustrates the waveform with constant input voltage (both sample periods 100 ms).

h. Ground pins 18 and 35 on REMOTE CONTROL connector (wire color code: pin 18, wht/blu/gray, pin 35, wht/blu/vio, pin 36, chassis ground, blk).

i. Figure 5-12c illustrates the waveform which should appear (both sample periods 1/60 sec).

5-78. COUNTER CHECKOUT.

5-79. A stepping device, combined with the truth tables is an invaluable tool for troubleshooting reversible counting units (RCU's). To construct a stepper, cut a perforated board or terminal board to accommodate nine small components and a switch. Wire the indicated components as shown in Figure 5-13.

5-80. Connecting the Stepper to R.C.U.

a. Open the connection at the input of whichever RCU is being investigated (Pin 6 of J6, 7, 8, and 9 or Pin 5 of J10).

b. Open the connection of the count up and count down terminals of the RCU. (Pins 8 and 9 of all RCU jacks.)

c. Connect a wire from the output of the stepper circuit (Junction R3-R5-C2) to the input jack of the RCU (see step a).

d. (1) If you wish to count up, connect a wire from the -30 volt supply of the stepper to pin 9 of the RCU's input jack, and connect pin 8 of the RCU's input jack to ground (pin 11).

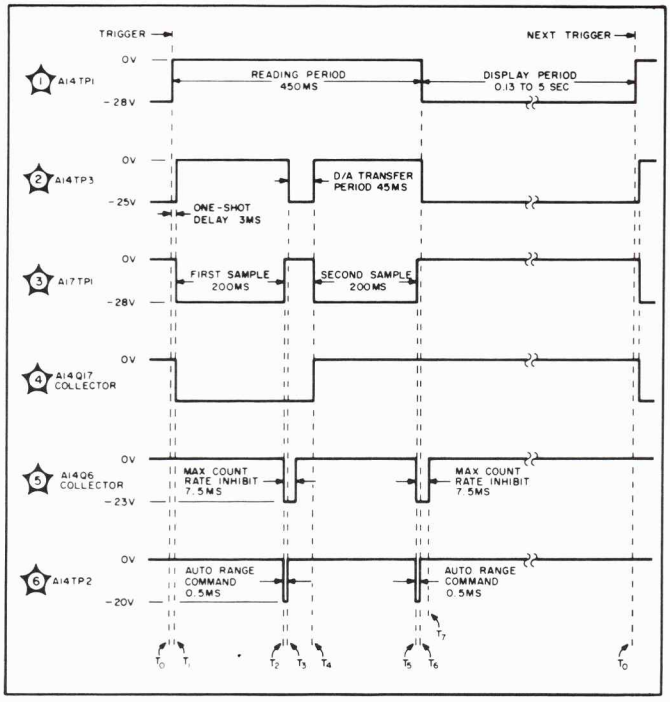


Figure 5-11. A14 Waveforms

(2) If you wish to count down, connect a wire from the -30 volt supply of the stepper to pin 8 of the RCU's input jack, and connect pin 9 of the RCU's input jack to ground (pin 11).

e. Connect a wire from the -35 V supply of the 3460B (at pin 7 of all DCU input jacks) to the stepper and its -30 V supply.

f. Connect a wire from the ground of the 3460B (at pin 11 of all DCU input jacks) to the stepper circuit ground.

5-81. Troubleshooting the Counter.

5-82. As an example we will consider 1248 logic. The same reasoning applies to 1224 logic.

a. Connect stepper as above.

b. Turn triggering rate to maximum, and range to automatic with no input to 3460B.

c. When the reading has stabilized, and when you are confident that the binaries have been reset as far as they will go, switch the RATE knob to "Hold" and observe the neon display of the binary in question (usually 0, 1, 2, 4, or 8 in the 1-2-4-8 counter). As an example let us suppose that the counter resets at 4. All binaries within the counter should be reset to "not true" according to the truth table. Referring to the 4 display, however, we find that it is possible that "C" binary is locked up in a "C true" condition.

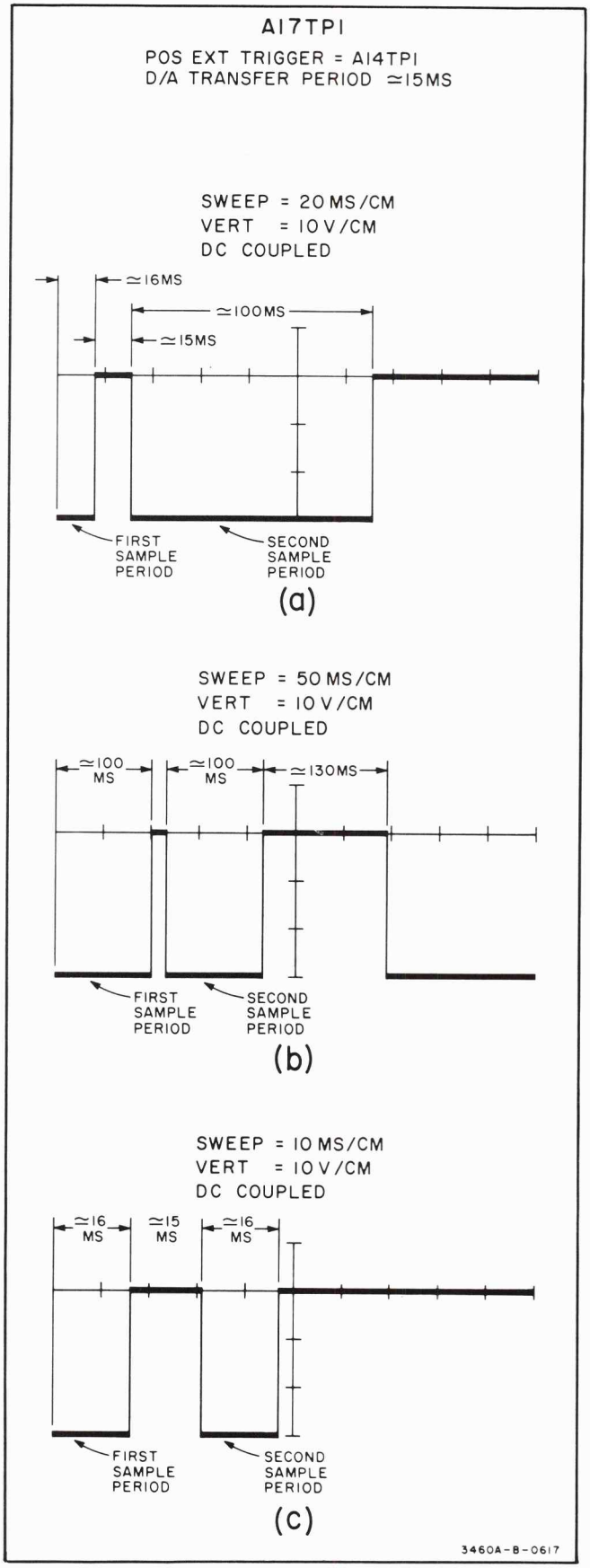


Figure 5-12. A17 Waveforms

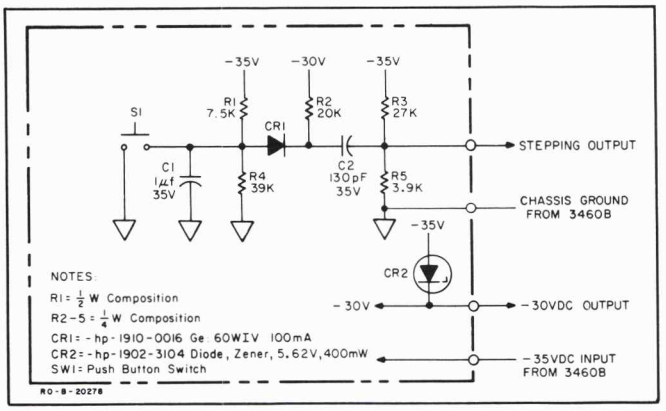


Figure 5-13. Stepper Schematic

d. Step the decade by switching the pushbutton of the stepper. If the decade counts 4567-4567-etc., the assumption that "C" binary is locked in "C true" is pretty well confirmed. (See Table 5-14.)

e. Step d leads us to Q6, the "C true" transistor. Step to a convenient reading and check out the Q6 area conventionally with a DC Voltmeter. When conducting the collector should read approximately -1.1 volts, the base approximately -1.25 volts and the emitter approximately -1 volt. When not conducting the collector should read approximately -29 volts, the base approximately -0.1 volts, and the emitter approximately -1.1 volts. If (in the example) Q6 looks normal, perhaps Q5 has opened.

5-83. By the same token if the count is 0123-0123-etc., in step d it would indicate that "C" binary was locked up in "not C true." (See Table 5-15.) Note that since the signal starts at A binary and since C binary is locked up the count will not affect D binary. Therefore, although "not C" is true in the 8 and 9 counts, the "D" binary will remain in the reset or "not D" state.

5-84. OVEN HEATER CHECK.

a. A DC Voltmeter (-hp- 412A) is required for this check.

b. Set Model 3460B to LOCAL; RANGE to 10 V; REAR-FRONT to FRONT; and TRIGGERING RATE full clockwise.

c. Connect dc voltmeter between Pins 3 and 6 on test jack (J25) within the Reference Power Supply Assembly.

d. After 10 minutes warm-up time, the voltmeter should indicate an "oven cycle" of zero volts to 15 volts (±1.5 V) and back to zero volts within less than 50 sec.

5-85. D-TO-A CONVERTER RELAY LOGIC TABLES.

5-86. Tables 5-16 and 5-17 identify the reed relay logic of the D-to-A Converter Relay Assembly (A21) with respect to the front panel display using the following code:

Table 5-14. Counting Sequence

Code				Display
1	2	4	8	
$\overline{A}$	$\overline{B}$	$\overline{C}$	$\overline{D}$	= 0
A	$\overline{B}$	$\overline{C}$	$\overline{D}$	= 1
$\overline{A}$	B	$\overline{C}$	$\overline{D}$	= 2
A	B	$\overline{C}$	D	= 3
$\overline{A}$	$\overline{B}$	C	$\overline{D}$	= 4
A	$\overline{B}$	C	$\overline{D}$	= 5
$\overline{A}$	B	C	$\overline{D}$	= 6
A	B	C	$\overline{D}$	= 7
$\overline{A}$	$\overline{B}$	$\overline{C}$	D	= 8
A	$\overline{B}$	$\overline{C}$	D	= 9

Table 5-15. Counting Sequence

Code				Display
1	2	4	8	
$\overline{A}$	$\overline{B}$	$\overline{C}$	$\overline{D}$	= 0
A	$\overline{B}$	$\overline{C}$	$\overline{D}$	= 1
$\overline{A}$	B	$\overline{C}$	$\overline{D}$	= 2
A	B	$\overline{C}$	$\overline{D}$	= 3
$\overline{A}$	$\overline{B}$	C	$\overline{D}$	= 4
A	$\overline{B}$	C	$\overline{D}$	= 5
$\overline{A}$	B	C	$\overline{D}$	= 6
A	B	C	$\overline{D}$	= 7
$\overline{A}$	$\overline{B}$	$\overline{C}$	D	= 8
A	$\overline{B}$	$\overline{C}$	D	= 9

O denotes de-energized relay
X denotes energized relay
* denotes relay contact to common point (ground)
ᵛ denotes relay contact to Reference Supply voltage.

Refer to Paragraph 5-67 for D-to-A relay checkout procedure.

5-87. Table 5-15 or 5-16 may be used to troubleshoot the D-to-A Relay Assembly (A21) by performing the following procedure.

a. Set Model 3460B to LOCAL; RANGE to 10 Volts; TRIGGERING RATE full clockwise, and short the INPUT.

b. Measure the output voltage from each reed relay by connecting a dc voltmeter between the appropriate pins on J19 (refer to schematic) and the LOW INPUT terminal.

c. The voltage measured from each reed relay should equal zero; if not, the reed relay on the D-to-A Relay Assembly or the respective storage binary on the RCD are malfunctioning

Table 5-16. D-to-A Converter Reed Relay Logic (1-2-4-8 Logic)

3460B DISPLAY	FIRST AND SECOND DIGIT			
	K2 (4)	K1(4[1])	K3(2)	K4(1)
0.0000	O*	O*	X*	X*
1.0000	O*	O*	X*	O[V]
2.0000	O*	O*	O[V]	O*
3.0000	O*	O*	O[V]	O[V]
4.0000	X[V]	O*	X*	X*
5.0000	X[V]	O*	X*	O[V]
6.0000	X[V]	O*	O[V]	X*
7.0000	X[V]	O*	O[V]	O[V]
8.0000	X[V]	X[V]	X*	X*
9.0000	X[V]	X[V]	X*	O[V]
10.0000	X[V]	X[V]	O[V]	X*
11.0000	X[V]	X[V]	O[V]	O[V]

3460B DISPLAY	THIRD DIGIT			
	K5 (8)	K6 (4)	K7 (2)	K8 (1)
0.0000	X*	X*	X*	X*
0.1000	X*	X*	X*	O[V]
0.2000	X*	X*	O[V]	X*
0.3000	X*	X*	O[V]	O[V]
0.4000	X*	O[V]	X*	X*
0.5000	X*	O[V]	X*	O[V]
0.6000	X*	O[V]	O[V]	X*
0.7000	X*	O[V]	O[V]	O[V]
0.8000	O[V]	X*	X*	X*
0.9000	O[V]	X*	X*	O[V]

3460B DISPLAY	FOURTH DIGIT			
	K9 (8)	K10 (4)	K11 (2)	K12 (1)
0.0000	X*	X*	X*	X*
0.0100	X*	X*	X*	O[V]
0.0200	X*	X*	O[V]	X*
0.0300	X*	X*	O[V]	O[V]
0.0400	X*	O[V]	X*	X*
0.0500	X*	O[V]	X*	O[V]
0.0600	X*	O[V]	O[V]	X*
0.0700	X*	O[V]	O[V]	O[V]
0.0800	O[V]	X*	X*	X*
0.0900	O[V]	X*	X*	O[V]

NOTES

O denotes de-energized relay.
X denotes energized relay.
* denotes relay contact to common point ③ (ground)
[V] denotes relay contact to Reference Supply Voltage (±13.960 V).

Table 5-17. D-to-A Converter Reed Relay Logic (1-2-2-4 Logic)

3460B DISPLAY	FIRST AND SECOND DIGIT			
	K2 (4)	K1 (4[1])	K3 (2)	K4 (1)
0.0000	O*	O*	X*	X*
1.0000	O*	O*	X*	O[V]
2.0000	O*	O*	O[V]	X*
3.0000	O*	O*	O[V]	O[V]
4.0000	O*	X[V]	X*	X*
5.0000	O*	X[V]	X*	O[V]
6.0000	X[V]	O*	O[V]	X*
7.0000	X[V]	O*	O[V]	O[V]
8.0000	X[V]	X[V]	X*	X*
9.0000	X[V]	X[V]	X*	O[V]
10.0000	X[V]	X[V]	O[V]	X*
11.0000	X[V]	X[V]	O[V]	O[V]

3460B DISPLAY	THIRD DIGIT			
	K5 (4)	K6 (2[1])	K7 (2)	K8 (1)
0.0000	X*	X*	X*	X*
0.1000	X*	X*	X*	O[V]
0.2000	X*	X*	O[V]	X*
0.3000	X*	X*	O[V]	O[V]
0.4000	X*	O[V]	O[V]	X*
0.5000	X*	O[V]	O[V]	O[V]
0.6000	O[V]	O[V]	X*	X*
0.7000	O[V]	O[V]	X*	O[V]
0.8000	O[V]	O[V]	O[V]	X*
0.9000	O[V]	O[V]	O[V]	O[V]

3460B DISPLAY	FOURTH DIGIT			
	K9 (4)	K10 (2[1])	K11 (2)	K12 (1)
0.0000	X*	X*	X*	X*
0.0100	X*	X*	X*	O[V]
0.0200	X*	X*	O[V]	X*
0.0300	X*	X*	O[V]	O[V]
0.0400	X*	O[V]	O[V]	X*
0.0500	X*	O[V]	O[V]	O[V]
0.0600	O[V]	O[V]	X*	X*
0.0700	O[V]	O[V]	X*	O[V]
0.0800	O[V]	O[V]	O[V]	X*
0.0900	O[V]	O[V]	O[V]	O[V]

NOTES

O denotes de-energized relay.
X denotes energized relay.
* denotes relay contact to common point ③ (ground).
[V] denotes relay contact to Reference Supply Voltage (±13.300 V).

PERFORMANCE CHECK TEST CARD

Hewlett-Packard Model 3460B
Digital Voltmeter

Test performed by _____
Date _____

Serial No. __ - _____

PARAGRAPH NUMBER AND TEST	TARGET READING	LIMITS	READING
5-7. ACCURACY	9 V	8.9995 to 9.0005 V	
	90 V	89.995 to 90.005 V	
	900 V	899.95 to 900.05 V	
Second Digit Linearity	9.0000	±5 counts	
	8.0000	±5 counts	
	7.0000	±4 counts	
	6.0000	±4 counts	
	5.0000	±4 counts	
	4.0000	±3 counts	
	3.0000	±3 counts	
	2.0000	±2 counts	
	1.0000	±2 counts	
	0.0000	±2 counts	
Third and Fourth Digit Linearity	0.9000 V	±2 counts	
	0.7000 V	±2 counts	
	0.5000 V	±2 counts	
	0.3000 V	±2 counts	
	0.1000 V	±2 counts	
	0.0900 V	±2 counts	
	0.0700 V	±2 counts	
	0.0500 V	±2 counts	
	0.0300 V	±2 counts	
	0.0100 V	±2 counts	
5-8. AUTOMATIC RANGING			
Uprange to 1000 V range at 121.00 V	at 121.00 V	none	
Downrange to 1 V range within 2 sample periods	within two sample periods	none	
5-9. INPUT RESISTANCE			
(expressed in volts) or	90.000 V	±3 counts	
(expressed in ohms)	10 megohms	±.03%	
5-10. DC COMMON MODE REJECTION			
500 V between guard and chassis	less than 0.00050	0 to 500 microvolts	
5-11. AC COMMON MODE REJECTION	less than 200 μ Vac	0 to 200 microvolts	
5-12. SUPERIMPOSED NOISE REJECTION			
600 mV peak, 60 Hz to input	less than 0.0006	0 to 600 microvolts	
5-13. SUPERIMPOSED NOISE REJECTION			
1 V Peak 58-62 Hz to input	less than 0.0025	0 to 2.5 millivolts	

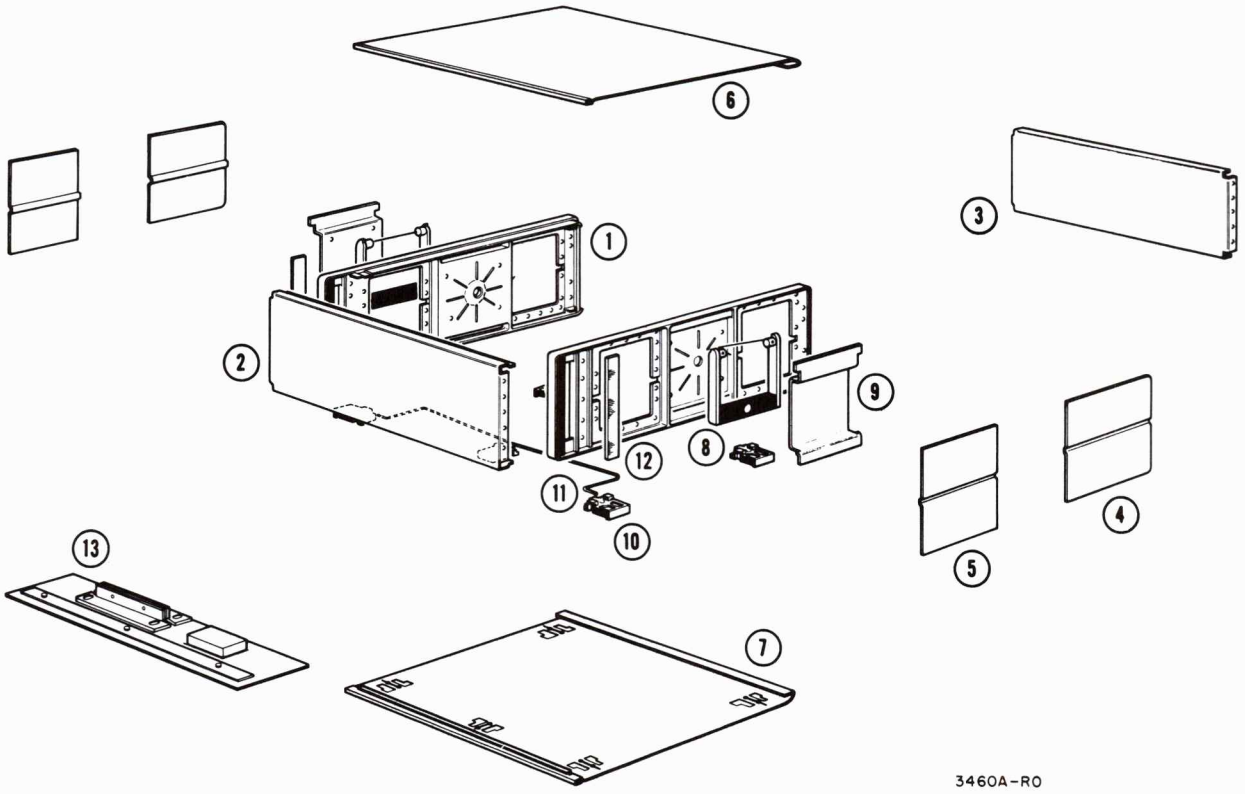
PERFORMANCE CHECK TEST CARD (Cont'd)

PARAGRAPH NUMBER AND TEST	TARGET READING	LIMITS	READING
5-16. REMOTE RANGING			
Grounded pin of J27:	Ranges to:		
Pin 30 (Wht/Yel)	1 V	go	_____
Pin 31 (Wht/Grn.)	10 V	go	_____
Pin 32 (Wht/Orn)	100 V	go	_____
Pin 33 (Wht/Brn)	1000 V	go	_____
Pin 28 (Wht/Blk)	Automatic	go	_____
5-17. MAXIMUM READING RATE			
Trigger at 15 Hz	15 triggers/sec	Proper Waveform	_____

5-18. RECORDER OUTPUT

Connect D.C. standard to input, digital recorder to output.

MODEL 3460B		DIGITAL RECORDER PRINTOUT		
RANGE	DISPLAY	9 8 7 6	5	4 3 2 1
1 V	+0.55555 V	0 0 5 5	5	5 5 0 5
1 V	+1.20100 V*	0 1 2 0	1 or 0	0 0 1 5
10 V	+ 2.2222 V	0 0 2 2	2	2 2 0 4
10 V	+11.1111 V	0 1 1 1	1	1 1 0 4
100 V	- 11.111 V	1 0 1 1	1	1 1 0 3
100 V	-120.100 V*	1 1 2 0	1 or 0	0 0 1 3
1000 V	- 555.55 V	1 0 5 5	5	5 5 0 2
1000 V	- 999.99 V	1 0 9 9	9	9 9 0 2



NO.	DESIGNATOR	DESCRIPTION	QTY.	PART NO.
1	MP1	FRAME ASS'Y	2	5060-0214
2	MP2	PANEL - FRONT	1	03460-00203
3	MP3	PANEL - REAR	1	03460-00202
4	MP4	COVER - REAR SIDE	2	5000-0098
5	MP5	COVER - FRONT SIDE	2	5000-0099
6	MP6	TOP COVER ASS'Y	1	03460-04109
7	MP7	BOT. COVER ASS'Y	1	03460-04110
8	MP8	HANDLE ASS'Y - SIDE	2	5060-0222
9	MP9	HANDLE RETAINER	2	5060-0766
10	MP10	FOOT ASS'Y	5	5060-0767
11	MP11	STAND - TILT	1	1490-0030
12	MP12	PLATE - FLUTED	2	5000-0051
13	MP13	KIT - ACCESSORY	1	03460-84402

Figure 6-1 Modular Cabinet

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alphameric order of their reference designators and indicates the description, -hp- part number of each part, together with any applicable notes, and provides the following:

a. The TQ column lists the total quantity of any part listed in the manual (including all optional boards). The total quantity of a part is given the first time the part number appears. To use the total parts column, find the total quantity of the part in question and subtract the number of these parts contained in optional boards that do not appear in your particular instrument. See Page 7-0.

b. Description of the part. (See list of abbreviations below.)

c. Typical manufacturer of the part in a five-digit code. (See Appendix A for list of manufacturers.)

d. Manufacturer's part number.

6-3. Misc parts are listed at the end of Table 6-1.

6-4. ORDERING INFORMATION.

6-5. To obtain replacement parts, address order or inquiry to your local Hewlett- Packard Field Office. (See Appendix B for list of office locations.) Identify parts by their Hewlett-Packard part numbers. Include instrument model and serial numbers.

6-6. NON-LISTED PARTS.

6-7. To obtain a part that is not listed, include:

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. Function and location of the part.

DESIGNATORS

A	= assembly	F	= fuse	MP	= mechanical part	TC	= thermocouple
B	= motor	FL	= filter	P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
BT	= battery	HR	= heater	Q	= transistor		
C	= capacitor	IC	= integrated circuit	QCR	= transistor-diode	W	= cable
CR	= diode	J	= jack	R	= resistor	X	= socket
DL	= delay line	K	= relay	RT	= thermistor	XDS	= lampholder
DS	= lamp	L	= inductor	S	= switch	XF	= fuseholder
E	= misc electronic part	M	= meter	T	= transformer	Z	= network

ABBREVIATIONS

Ag	= silver	ID	= inside diameter	ns	= nanosecond (s) = 10^{-9} seconds	sl	= slide
Al	= aluminum	impg	= impregnated	nsr	= not separately replaceable	SPDT	= single-pole double-throw
A	= ampere (s)	incd	= incandescent			SPST	= single-pole single-throw
Au	= gold	ins	= insulation (ed)				
C	= capacitor	kΩ	= kilohm (s) = 10^{+3} ohms	Ω	= ohm (s)	Ta	= tantalum
cer	= ceramic	kHz	= kilohertz = 10^{+3} hertz	obd	= order by description	TC	= temperature coefficient
coef	= coefficient			OD	= outside diameter	TiO_2	= titanium dioxide
com	= common	L	= inductor				
comp	= composition	lin	= linear taper	p	= peak	tog	= toggle
conn	= connection	log	= logarithmic taper	pc	= printed circuit	tol	= tolerance
dep	= deposited	m	= milli = 10^{-3}	pF	= picofarad (s) = 10^{-12} farads	trim	= trimmer
DPDT	= double-pole double-throw	mA	= milliampere (s) = 10^{-3} amperes	piv	= peak inverse voltage	TSTR	= transistor
DPST	= double-pole single-throw	MHz	= megahertz = 10^{+6} hertz	p/o	= part of	V	= volt (s)
		MΩ	= megohm (s) = 10^{+6} ohms	pos	= position (s)	vacw	= alternating current working voltage
elect	= electrolytic	met flm	= metal film	poly	= polystyrene	var	= variable
encap	= encapsulated	mfr	= manufacturer	pot	= potentiometer	vdcw	= direct current working voltage
F	= farad (s)	mtg	= mounting	p-p	= peak-to-peak		
FET	= field effect transistor	mV	= millivolt (s) = 10^{-3} volts	ppm	= parts per million	W	= watt (s)
fxd	= fixed	μ	= micro = 10^{-6}	prec	= precision (temperature coefficient, long term stability, and/or tolerance)	w/	= with
GaAs	= gallium arsenide	μV	= microvolt (s) = 10^{-6} volts			wiv	= working inverse voltage
GHz	= gigahertz = 10^{+9} hertz	my	= Mylar ®			w/o	= without
gd	= guard (ed)	nA	= nanoampere (s) = 10^{-9} amperes	R	= resistor	ww	= wirewound
Ge	= germanium	NC	= normally closed	Rh	= rhodium	*	= optimum value selected at factory, average value shown (part may be omitted)
grd	= ground (ed)	Ne	= neon	rms	= root-mean-square		
H	= henry (ies)	NO	= normally open	rot	= rotary		
Hg	= mercury	NPO	= negative positive zero (zero temperature coefficient)	Se	= selenium	**	= no standard type number assigned (selected or special type)
Hz	= hertz (cycle (s) per second)			sect	= section (s)		
				Si	= silicon		

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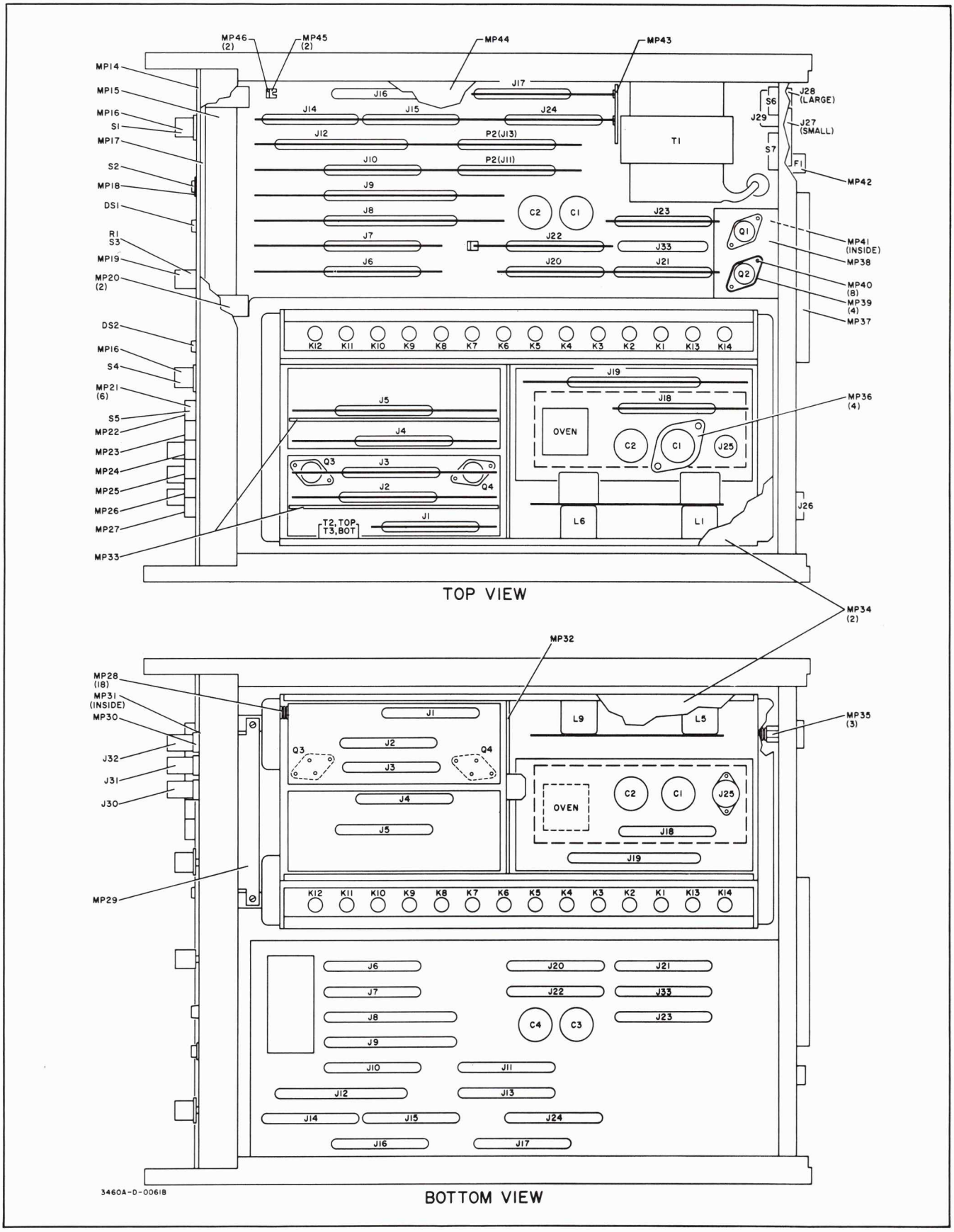


Figure 6-2. Mechanical Parts

DESIGNATOR	DESCRIPTION	QUANTITY	-hp- PART NO.
MP1 thru MP13	See Figure 7-1		
MP14	Strip: trim	1	03460-04301
MP15	Holder: decimal	1	03460-23301
MP16	Knob: bar (LOCAL-REMOTE TRIGGERING) and (REAR-FRONT)	2	0370-0104
MP17	Window: polaroid	1	1000-0024
MP18	Nut: knurled 54 edges black anodized Al	1	0590-0122
MP19	Knob: (TRIGGERING RATE)	1	0370-0103
MP20	Support: readout	2	5040-0640
MP21	Knob: pushbutton (RANGE)	6	0370-0121
MP22	Label: pushbutton (AUTO)	1	5000-0328
MP23	Label: pushbutton (1)	1	5000-0329
MP24	Label: pushbutton (10)	1	5000-0330
MP25	Label: pushbutton (100)	1	5000-0331
MP26	Label: pushbutton (1000)	1	5000-0332
MP27	Label: pushbutton (REMOTE)	1	5000-0333
MP28	Spacer: insulating	18	5040-0639
MP29	Cover: switch	1	03460-04103
MP30	Insulator: binding post (front)	1	0340-0159
MP31	Insulator: binding post (rear)	3	0340-0100
MP32	Gusset: center guard	1	03460-01219
MP33	Shield	2	03460-01202
MP34	Cover: guard (top)	1	03460-04101
	Cover: guard (bottom)	1	03460-04105
MP35	Spacer: guard	3	03460-24701
MP36	Insulator: capacitor	4	1520-0002
MP37	Filter: air element	1	03460-01230
MP38	Shroud: fan	1	03460-01220
MP39	Insulator: transistor mtg	4	1200-0043
MP40	Insulator: bushing nylon	8	1200-0081
MP41	Blade: fan propeller	1	3160-0029
MP42	Holder: fuse extractor post type	1	1400-0084
MP43	Bracket: pc support	1	03460-01221
MP44	Support: board	1	03460-04102
MP45	Guide: pc	2	5040-0601
MP46	Bracket: board	2	5020-0656

Figure 6-2. Mechanical Parts

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A1	**03460-66501**	**1**	**Assembly: Integrator**	**-hp-**		
C1	0140-0151	8	C: fxd mica 820 pF 2% 300 vdcw	04062	RDM15F821G3S	
C2	0160-0181	1	C: fxd mica 30 pF 5%	04062	RDM15E300J3S	
C3	0140-0208	1	C: fxd mica 680 pF 5% 300 vdcw	04062	RDM15F681J3C	
C4	0180-0155	1	C: fxd Ta elect 2.2 microfarads 20% 20 vdcw	56289	150D225X0020AZ	
C5	0160-0174	2	C: fxd cer 0.47 microfarads +80% -20% 25 vdcw	56289	5C11A	obd
C6	0170-0066	1	C: fxd my 0.027 microfarads 10% 200 vdcw	56289	192P27392	
CR1	1902-0031	1	Diode: breakdown 12.7 V 5% 400 mW	01281	DS18270A	
CR2, CR3	1901-0025	180	Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
Q1A, Q1B	1854-0221	2	TSTR: Si NPN dual	-hp-		
Q2			Not assigned			
Q3	1854-0003	9	TSTR: Si NPN**	-hp-		
Q4	1850-0096	1	TSTR: Ge PNP 2N2189	01295	2N2189	
Q5	1854-0003		TSTR: Si NPN**	-hp-		
R1	0757-0342	3	R: fxd prec met flm 100 kilohms 1% 1/4 W	75042	CEB T-O	obd
R2	0757-0787	1	R: fxd prec met flm 392 kilohms 1% 1/4 W	19701	MF6C T-O	obd
R3, R4	0757-0785	1	R: fxd prec met flm 274 kilohms 1% 1/4 W	19701	MF6C T-O	obd
R5	0757-0746	4	R: fxd prec met flm 4750 ohms 1% 1/4 W	75042	CEB T-O	obd
R6	0757-0342		R: fxd prec met flm 100 kilohms 1% 1/4 W	75042	CEB T-O	obd
R7	0757-0789	1	R: fxd prec met flm 475 kilohms 1% 1/4 W	19701	MF6C T-O	obd
R8	0757-0746		R: fxd prec met flm 4750 ohms 1% 1/4 W	75042	CEB T-O	obd
R9	2100-0806	2	R: var ww 5000 ohms 5% 1W	75042	CT-106-2	obd
R10	0757-0746		R: fxd prec met flm 4750 ohms 1% 1/4 W	75042	CEB T-O	obd
R11	0757-0789		R: fxd prec met flm 475 kilohms 1% 1/4 W	19701	MF6C T-O	obd
R12	0687-2731	1	R: fxd comp 27 kilohms 10% 1/2 W	01121	EB2731	
R13	0757-0729	1	R: fxd prec met flm 681 ohms 1% 1/4 W	19701	MF6C T-O	obd
R14	0687-3911	1	R: fxd comp 390 ohms 10% 1/2 W	01121	EB3911	
R15	0687-5621	3	R: fxd comp 5600 ohms 10% 1/2 W	01121	EB5621	
R16	0687-4721	1	R: fxd comp 4700 ohms 10% 1/2 W	01121	EB4721	
R17	0687-1021	2	R: fxd comp 1000 ohms 10% 1/2 W	01121	EB1021	
R18	0687-1831	1	R: fxd comp 18 kilohms 10% 1/2 W	01121	EB1831	
R19	0687-1521	8	R: fxd comp 1500 ohms 10% 1/2 W	01121	EB1521	
R20	0683-1025	7	R: fxd comp 1000 ohms 5% 1/4 W Added at Serial No. 709-00176	01121	CB1025	
A2	**03460-66502**	**1**	**Assembly: Precision Current Pulse Generator**	**-hp-**		
C1, C2	0160-0332	4	C: fxd mica 133 pF 1%	04062	RDM15FF3C	
C3	0140-0152	5	C: fxd mica 1000 pF 5% 300 vdcw	04062	DM16F102J	
C4	0160-0161	5	C: fxd 0.01 microfarads 10% 200 vdcw	56289	192P10392	
C5	0160-2742	2	C: fxd porcelain 150 pF 1% 200 vdcw	95275	VY10CA (151)F-R	
C6, C7	0160-0332		C: fxd mica 133 pF 1%	04062	RDM15F(133)F3C	
C8	0140-0152		C: fxd mica 1000 pF 5% 300 vdcw	04062	DM16F102J	
C9	0160-0161		C: fxd 0.01 microfarads 10% 200 vdcw	56289	192P10392	
C10	0160-0988		C: fxd porcelain 147 pF 1% 500 vdcw	75275	VY12CA(147)F-R	
CR1 thru CR10	1901-0040	12	Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	07910	CD6319	obd
Q1 thru Q3	1854-0005	4	TSTR: Si NPN 2N708	07263	2N708	obd
Q4	1850-0074	2	TSTR: Ge PNP 2N1396	86684	2N1396	
Q5	1854-0005		TSTR: Si NPN 2N708	07263	2N708	obd
Q6	1854-0036	1	TSTR: Si NPN 2N2958	04713	2N2958	
Q7	1850-0074		TSTR: Ge PNP 2N1396	86684	2N1396	
Q8, Q9	1853-0001	1	TSTR: Si PNP**	07263	S3251	
Q10	1854-0064	1	TSTR: Si PNP**	-hp-		

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A2 (Cont'd)						
Q11	1853-0016	1	TSTR: Si PNP 2N3638	07263	2N3638	
Q12	1853-0006	1	TSTR: Si PNP 2N3134	04713	2N3134	
R1	0757-0924	6	R: fxd met flm 1000 ohms 2% 1/8 W	19701	MF07C	obd
R2	0757-0952	4	R: fxd met flm 15 kilohms 2% 1/8 W	19701	MF07C	obd
R3	0757-0974	4	R: fxd met flm 120 kilohms 2% 1/8 W	19701	MF07C	obd
R4	0757-0952		R: fxd met flm 15 kilohms 2% 1/8 W	19701	MF07C	obd
R5	2100-0740	1	R: var ww 500 ohms 5% 1 W	75042	CT-106-2	obd
R6	0757-0954	3	R: fxd met flm 18 kilohms 2% 1/8 W	19701	MF07C	obd
R7	0757-0948	2	R: fxd met flm 10 kilohms 2% 1/8 W	19701	MF07C	obd
R8	0757-0974		R: fxd met flm 120 kilohms 2% 1/8 W	19701	MF07C	obd
R9	0757-0956	3	R: fxd met flm 22 kilohms 2% 1/8 W	19701	MF07C	obd
R10	0757-0962	3	R: fxd met flm 39 kilohms 2% 1/8 W	19701	MF07C	obd
R11	0757-0924		R: fxd met flm 1000 ohms 2% 1/8 W	19701	MF07C	obd
R12 thru R14	0757-0940	2	R: fxd met flm 4700 ohms 2% 1/8 W	19701	MF07C	obd
R15	0757-0958	2	R: fxd met flm 27 kilohms 2% 1/8 W	19701	MF07C	obd
R16	0811-1337	2	R: fxd prec ww 20 kilohms 3% 3 W	00213	1200S	obd
R17	0757-0338	2	R: fxd prec met flm 1.00 kilohms 1% 1/4 W	19701	MF6C T-O	obd
R18, R19	0757-0924		R: fxd met flm 1000 ohms 2% 1/8 W	19701	MF07C	obd
R20	0757-0952		R: fxd met flm 15 kilohms 2% 1/8 W	19701	MF07C	obd
R21	0757-0974		R: fxd met flm 120 kilohms 2% 1/8 W	19701	MF07C	obd
R22	0757-0952		R: fxd met flm 15 kilohms 2% 1/8 W	19701	MF07C	obd
R23	0757-0954		R: fxd met flm 18 kilohms 2% 1/8 W	19701	MF07C	obd
R24	0757-0948		R: fxd met flm 10 kilohms 2% 1/8 W	19701	MF07C	obd
R25	0757-0974		R: fxd met flm 120 kilohms 2% 1/8 W	19701	MF07C	obd
R26	0757-0956		R: fxd met flm 22 kilohms 2% 1/8 W	19701	MF07C	obd
R27	0757-0962		R: fxd met flm 39 kilohms 2% 1/8 W	19701	MF07C	obd
R28	0757-0924		R: fxd met flm 1000 ohms 2% 1/8 W	19701	MF07C	obd
R29 thru R31	0757-0940		R: fxd met flm 4700 ohms 2% 1/8 W	19701	MF07C	obd
R32	0757-0944	6	R: fxd met flm 6800 ohms 2% 1/8 W	19701	MF07C	obd
R33	0757-0958		R: fxd met flm 27 kilohms 2% 1/8 W	19701	MF07C	obd
R34	0811-1337		R: fxd prec ww 20 kilohms 3% 3 W	00213	1200S	obd
R35	2100-0715	2	R: var 1000 ohms 10% 25 turns 1 W	73138	55P	obd
R36	0757-0338		R: fxd prec met flm 1.00 kilohms 1% 1/4 W	19701	MF6C T-O	obd
R37	0757-0924		R: fxd met flm 1000 ohms 2% 1/8 W	19701	MF07C	obd
R38	2100-0715		R: var 1000 ohms 10% 25 turns 1 W	73138	55P	obd
R39	2100-0740	1	R: var ww 500 ohms 5% 1 W	75042	CT-106-2	obd
R40	0757-0944		R: fxd met flm 6800 ohms 2% 1/8 W	19701	MF07C	obd
R41	0757-0910	1	R: fxd met flm 270 ohms 2% 1/8 W	19701	MF07C	obd
R42, R43	0757-0813		R: fxd met flm 475 ohms 1% 1/2 W	19701	MF7C T-O	obd
T1	9100-0332	1	Transformer: pulse	01961	5116	obd
A3	**03460-66503**	**1**	**Assembly: Plus and Minus 17.5 Volt Power Supply**	**-hp-**		
C1 thru C4	0180-0381	4	C: fxd Al elect 150 microfarads +100% -10% 40 vdcw	56289	34D157H040FL4	
C5	0180-0049	1	C: fxd Al elect 20 microfarads 50 vdcw	56289	D33909	
C6, C7	0180-0094	4	C: fxd Al elect 100 microfarads +100% -10% 25 vdcw	56289	30D107G025DH4	
CR1 thru CR8	1901-0045	12	Diode: Si 100 piv	04713	obd	
CR9	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	
CR10	1902-0057	2	Diode: Si breakdown 6.49 V 5% 400 mW	01281	PS18242A	
CR11	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	
CR12	1902-0057		Diode: Si breakdown 6.49 V 5% 400 mW	01281	PS18242A	
CR13	1902-0777	1	Diode: breakdown IN825 (aged)	03877	IN825	
Q1	1853-0010	2	TSTR: Si PNP**	-hp-		
Q2	1854-0014	2	TSTR: Si NPN dual**	-hp-		

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A3 (Cont'd)						
Q3	1853-0009	3	TSTR: Si PNP**	-hp-		
Q4	1854-0014		TSTR: Si NPN dual**	-hp-		
R1	0687-5611	3	R: fxd comp 560 ohms 10% 1/2 W	01121	EB5611	
R2	0687-1021		R: fxd comp 1000 ohms 10% 1/2 W	01121	EB1021	
R3	0727-0445	2	R: fxd prec carbon flm 2 ohms 1% 1/2 W	82647	CD1/2 BR	obd
R4	0687-1521		R: fxd comp 1500 ohms 10% 1/2 W	01121	EB1521	
R5	2100-0354	1	R: var ww 1 kilohm 10% 1 W	09145	114106	obd
R6	0811-1364	4	R: prec ww 1000 ohms 0.5% 1/4 W	01686	7009	obd
R7	0811-1366	1	R: prec ww 1075 ohms 0.5% 1/4 W	01686	7009	obd
R8	0757-0944		R: fxd met flm 6800 ohms 2% 1/8 W	19701	MF07C	obd
R9	0811-1364		R: prec ww 1000 ohms 0.5% 1/4 W	01686	7009	obd
R10	0757-0935	2	R: fxd met flm 3000 ohms 2% 1/8 W	19701	MF07C	obd
R11	0757-0944		R: fxd met flm 6800 ohms 2% 1/8 W	19701	MF07C	obd
R12	0811-0071	1	R: fxd prec power ww 1520 ohms 1% 3 W	00213	RS-2B	obd
R13	0727-0445		R: fxd carbon flm 2 ohms 1% 1/2 W	82647	CD1/2BR	obd
R14	0687-6821	2	R: fxd comp 6800 ohms 10% 1/2 W	01121	EB6821	
R15	0687-1521		R: fxd comp 1500 ohms 10% 1/2 W	01121	EB1521	
R16	0811-1365	1	R: prec ww 590 ohms 0.5% 1/4 W	01686	7009	obd
R17	0811-1364		R: prec ww 1000 ohms 0.5% 1/4 W	01686	7009	obd
R18	0757-0935		R: fxd met flm 3000 ohms 2% 1/8 W	19701	MF07C	obd
R19, R20	0757-0944		R: fxd met flm 6800 ohms 2% 1/8 W	19701	MF07C	obd
R21	0811-1367	1	R: fxd prec ww 2180 ohms 0.5% 1/4 W	01686	7009	obd
R22	0811-1364		R: prec ww 1000 ohms 0.5% 1/4 W	01686	7000	obd
R23	0687-1541	1	R: fxd comp 150 K 10% 1/2 W	01121	EB1541	
A4	**03460-66504**	**1**	**Assembly: Plus and Minus 25 Volt Power Supply**	**-hp-**		
C1, C2	0180-0149	4	C: fxd Al elect 65 μF +100% -10% 60 vdcw	56289	Type 30D	obd
C3, C4	0180-0050	5	C: fxd Al elect 40 μF +100% - 15% 50 vdcw	56289	D32538	
C5, C6	0180-0149		C: fxd Al elect 65 μF +100% - 10% 60 vdcw	56289	Type 30D	obd
C7, C8	0180-0050		C: fxd Al elect 40 μF +100% - 15% 50 vdcw	56289	D32538	
C9, C10	0180-0379	2	C: fxd Al elect 5 μF +75% - 10% 350 vdcw	56289	34D505G350 EJ4	
C11, C12	0150-0121	7	C: fxd cer 0.1 μF +80% - 20% 50 vdcw	56289	5C50A	obd
C13, C14	0160-0170		C: fxd cer 0.22 μF 25 vdcw added at Serial No. 732-00401	56289	SC9B	
CR1 thru CR4	1901-0026	12	Diode: Si 200 piv	05713	obd	
CR5	1901-0036	1	Diode: Si 1000 piv	01295	obd	
CR6, CR7	1902-3259	2	Diode: Si breakdown 24.3 V 5% 400 mW	07910	CD 35817	
Q1	1853-0030	1	TSTR: Si PNP**	03877	obd	
	1205-0011	2	Heat dissipator: semiconductor (for Q1)	-hp-		
Q2	1850-0040	3	TSTR: Ge PNP**	-hp-		
Q3, Q4	1854-0003		TSTR: Si NPN**	-hp-		
	1205-0011		Heat dissipator: semiconductor (for Q3)	-hp-		
R1	0687-1521		R: fxd comp 1500 ohms 10% 1/2 W	01121	EB1521	
R2	0757-0797	2	R: fxd prec met flm 90.9 ohms 1% 1/2W	19701	MF7C T-O	obd
R3	0687-1521		R: fxd comp 1500 ohms 10% 1/2W	01121	EB1521	
R4, R5	0687-5621		R: fxd comp 5600 ohms 10% 1/2W	01121	EB5621	
R6	0757-0726	1	R: fxd prec met flm 511 ohms 1% 1/4W	19701	MF6C T-O	obd
R7	0757-0744	2	R: fxd prec met flm 3920 ohms 1% 1/4W	19701	MF6C T-O	obd
R8, R9	0687-1521		R: fxd comp 1500 ohms 10% 1/2W	01121	EB1521	
R10			Not assigned			
R11	2100-0741	1	R: var ww 5000 ohms 5% 1W	75042	CT-100	obd
R12	0687-6841	1	R: fxd 680 K 10% 1/2W	01121	EB6841	
R13	0687-6821		R: fxd comp 6800 ohms 10% 1/2W	01121	EB6821	
R14	0757-0797		R: fxd prec met flm 90.9 ohms 1% 1/2W	19701	MF7C T-O	obd
R15	2100-0806	1	R: var ww 5000 ohms 5% 1W	75042	CT-106-2	obd

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A4 (Cont'd)						
R16	0757-0744		R: fxd prec met flm 3920 ohms 1% 1/4W	19701	MF6C T-O	obd
R17	0757-0760	1	R: fxd prec met flm 20.0 K 1% 1/4W	19701	MF6C T-O	obd
A5	**03460-66505**	**1**	**Assembly: Voltage-to-Current Converter**	**-hp-**		
A1	5060-5936	1	Assembly: photochopper	-hp-		
	5060-5935		Assembly: Neon Oscillator p/o A5A1			
	1990-0095		Photo conductor block p/o A5A1			
			NOTE For component part numbers see Page 7-6.			
C1	0160-0144	1	C: fxd poly 0.25 μF 2% 50 vdcw	56289	114P2542R554	
C2	0180-0094		C: fxd Al elect 100 μF +100% -10% 25 vdcw	56289	30D107G025 DH4	
C3	0140-0152		C: fxd mica 1000 pF 5% 300 vdcw	04062	DM16F102J	
C4	0180-0105	4	C: fxd Al elect 50 μF +100% -10% 25 vdcw	56289	D34114	
C5, C6	0140-0198	10	C: fxd mica 200 pF 5% 300 vdcw	04062	RDM15F201 J3C	
C7, C8	0160-0174	2	C: fxd cer 0.47 μF +80% -20% 25 vdcw	56289	5C11A	obd
C9	0170-0029	1	C: fxd poly 0.01 μF 10% 50 vdcw	56289	P148073	
C10	0160-2303	1	C: fxd poly 0.22 μF 10% 50 vdcw	56289	144P2249R 559	
C11	0180-0105		C: fxd Al elect 50 μF +100% -10% 25 vdcw	56289	D34114	
C12	0180-0059	2	C: fxd elect 10 μF +100% -10% 25 vdcw	56289	30D106G025 BB4	
C13	0180-1719	1	C: fxd Ta elect 22 μF 10% 25 vdcw	56289	1090226X90 25C2	
C14	0150-0024	1	C: fxd cer 0.02 μF +80% -20% 600 vdcw	72982	841-000-Z5U-203Z	
C15	0160-0859	1	C: fxd my 1 μF 10% 50 vdcw	56289	148P	obd
C16	0170-0040	1	C: fxd 0.047 μF 10%	56289	192P47392A	
C17	0150-0084	1	C: fxd cer 0.1 μF +80% -20% 50 vdcw	56289	33C41	obd
C18	0180-0294	1	C: fxd Ta elect 390 μF 20% 10 vdcw	56289	109D397X00 10T2	
C19	0180-0060	1	C: fxd elect 200 μF +100% -10% 3 vdcw	56289	30D207G003DC4	
CR1 thru CR4	1901-0156	4	Diode: Si 50 ma at +1 V 20 wiv	01281	PS5553	
CR5, CR6	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR7, CR8	1902-0022	4	Diode: breakdown 2.67 V 10% 4 mW	07910	CD35540	
CR9	1901-0040		Diode: Si 30 mA at +1 V 30 piv 12 pF 2ns	07910	CD6319	obd
CR10	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR11, CR12	1902-0022		Diode: breakdown 2.67 V 10% 4mW	07910	CD35540	
CR13, CR14	1901-0040		Diode: Si 30 mA at +1 V 30 piv 12 pF 2ns	07910	CD6319	obd
Q1, Q2	1855-0015	2	TSTR: matched pair FET**	-hp-		
Q3	1854-0003		TSTR: Si NPN**	-hp-		
Q4	1853-0009		TSTR: SI PNP**	-hp-		
Q5	1854-0003		TSTR: Si NPN**	-hp-		
Q6	1853-0009		TSTR: Si PNP**	-hp-		
Q7	1855-0014	1	TSTR: FET**	-hp-		
Q8	1854-0003		TSTR: Si NPN**	-hp-		
Q9	1854-0033	6	TSTR: Si NPN 2N3391	24446	2N3391	
Q10	1854-0045	1	TSTR: Si NPN**	-hp-		
Q11	1853-0010		TSTR: Si PNP**	-hp-		
Q12	1854-0033		TSTR: Si NPN 2N3391	24446	2N3391	
R1	0757-0169	1	R: fxd prec met flm 511 K 1% 1/4 W	75042	CEB T-O	obd
R2	0811-1336	1	R: fxd prec ww 13 K 3% 3 W	00213	1200S	obd
R3	0811-1335	2	R: fxd prec ww 11 K 3% 3 W	00213	1200S	obd

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A5 (Cont'd)						
R4	0757-0948	1	R: fxd met flm 10 kilohms 2% 1/8 W	19701	MF07C	obd
R5	0683-3935	79	R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935	
R6	0683-2725	2	R: fxd comp 2700 ohms 5% 1/4 W	01121	CB2725	
R7	0683-1825	1	R: fxd comp 1800 ohms 5% 1/4 W	01121	CB1825	
R8, R9	0687-5611		R: fxd comp 560 ohms 10% 1/2 W	01121	EB5611	
R10, R11	0683-2205	2	R: fxd comp 22 ohms 5% 1/4 W	01121	CB2205	
R12	0683-4715	3	R: fxd comp 470 ohms 5% 1/4 W	01121	CB4715	
R13	0757-0769	1	R: fxd prec met flm 51.1 K 1% 1/4 W	19701	MF6C T-O	obd
R14	0757-0945	1	R: fxd met flm 7500 ohms 2% 1/8 W	19701	MF07C	obd
R15	0811-1334	1	R: fxd prec ww 1350 ohms 3% 3 W	00213	1200S	obd
R16	0730-0144	1	R: fxd prec carbon flm 10.52 megohms 1% 1 W	91637	DC-1	obd
R17	0757-0976	1	R: fxd met flm 150 kilohms 2% 1/8 W	19701	MF07C	obd
R18	0757-0960	1	R: fxd met flm 33 kilohms 2% 1/8 W	19701	MF07C	obd
R19	0683-2735	60	R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R20	0683-1845	1	R: fxd comp 180 kilohms 5% 1/4 W	01121	CB1845	
R21	0757-0917	1	R: fxd met flm 510 ohms 2% 1/8 W	19701	MF07C	obd
R22	0757-0942	1	R: fxd met flm 5600 ohms 2% 1/8 W	19701	MF07C	obd
R23	0683-1835	59	R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R24	0683-5625	4	R: fxd comp 5600 ohms 5% 1/4 W	01121	CB5625	
R25	0683-5635	64	R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635	
R26	0683-1035	80	R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R27	0683-5135	10	R: fxd comp 51 kilohms 5% 1/4 W	01121	CB5135	
R28	0683-3315	1	R: fxd comp 330 ohms 5% 1/4 W	01121	CB5135	
R29	0683-5625		R: fxd comp 5600 ohms 5% 1/4 W	01121	CB5625	
R30	2100-0912	1	R: var comp lin 5000 ohms 20% 1/5 W	71590	Model 1	obd
R31	0683-2725		R: fxd comp 2700 ohms 5% 1/4 W	01121	CB2725	
R32	0683-6835	9	R: fxd comp 68 kilohms 5% 1/4 W	01121	CB6835	
R33	0757-0931	3	R: fxd met flm 2000 ohms 2% 1/8 W	19701	MF07C	obd
R34	0683-2025	4	R: fxd comp 2000 ohms 5% 1/4 W	01121	CB2025	
R35	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R36	0683-8225	13	R: fxd comp 8200 ohms 5% 1/4 W	01121	CB8225	
R37	0683-2235	53	R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R38	0757-0972	1	R: fxd met flm 100 kilohms 2% 1/8 W	19701	MF07C	obd
R39	0811-1335		R: fxd prec ww 11 kilohms 3% 3 W	00213	1200S	obd
R40	0683-3325	65	R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R41, R42	0757-0931		R: fxd met flm 2000 ohms 2% 1/8 W	19701	MF07C	obd
A6, A7			**Not assigned**			
A8	**03460-67502**		**Assembly: Digital-to-Analog Resistors**	**-hp-**		
			NOTE Calibrated assembly available on exchange basis, under -hp- Part No. 03460-67504.			
P1	1251-1119	1	Connector: pc 22 pin male contact adapter	000XX	GP-XMD-622S (3-U62)	
R1 thru R14	0811-1102	14	R: set matched fxd prec ww	-hp-		

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A8 (Cont'd)			NOTE See Figure 7-18			
R15	2100-1448	6	R: var ww 200 ohms 10% 1 W	80294	3057Y-1-201	
R16, R17			Not assigned			
R18, R19	0811-1104	6	R: set matched fxd prec ww	-hp-		
R20			Not assigned			
R21	0757-0493	2	R: fxd prec met flm 15 ohms 1% 1/4 W	75042	CEB T-O	obd
R22	2100-1484	2	R: var ww lin 1000 ohms 5% 3/4 W	12697	76JA3 CM32589	
R23, R24	2100-1481	4	R: var ww lin 50 ohms 5% 3/4 W	12697	76JA3 CM32464	
R25	2100-1482	2	R: var ww lin 100 ohms 5% 3/4 W	12697	76JA3 CM32465	
R26	2100-1483	3	R: var ww lin 200 ohms 5% 3/4 W	12697	76JA3 CM32466	
R27	2100-1478	3	R: var ww 50 ohms 10% 1 W	80294	3057Y-1-500	
R28, R29	2100-0325	3	R: var ww 100 ohms 10% 1 W	80294	3057Y-1-101	
R30	2100-1448		R: var ww 200 ohms 10% 1 W	80294	3057Y-1-201	
A9, A10 †	**03460-66509**	**2**	**Assembly: Reversible Counting Decade (1-2-2-4)**	**-hp-**		
A9A1, A10A1	03460-69503		Assembly: Nixie Decoding includes DS1A-H, R69, V1, and:	-hp-		
	0845-0001	12	Resistive network	71590	obd	
	0905-0043	11	Gasket: rubber	-hp-		
	0905-0051	11	Gasket: felt	-hp-		
	1990-0009	6	Plate: photoconductor	-hp-		
	2140-0044	112	Lamp: neon	-hp-		
	5040-4569	5	Socket: nixie	-hp-		
	5212A-83C	5	Cover column	-hp-		
	03440-63001	5	Block: photoconductor	-hp-		
	05212-0011	11	Shield: photo plate	-hp-		
C1, C2	0140-0195	47	C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C3, C4	0140-0194	45	C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300V	
C5, C6	0140-0218	15	C: fxd mica 160 pF 2%	04062	RDM15F161G3C	
C7, C8	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300V	
C9, C10	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C11, C12	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300V	
C13, C14	0140-0218		C: fxd mica 160 pF 2%	04062	RDM15F161G3C	
C15	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C16, C17	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300V	
C18	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
CR1, CR2	1901-0025		Diode: Si 100 ma at +1 V 100 piv 12 pF	93332	D3072	obd
CR3 thru CR7	1910-0016	223	Diode: Ge 60 wiv	03877	S3185G	
CR8, CR9	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR10 thru CR16	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR17, CR18	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR19 thru CR24	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR25, CR26	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR27 thru CR33	1901-0016		Diode: Ge 60 wiv	03877	S3185G	
DS1A thru DS1H	2140-0044	80	Lamp: neon	-hp-		
DS2	1970-0009	7	Tube: special purpose 10 digit numeral indicator	83594	B5991	
Q1 thru Q8	1850-0062	134	TSTR: Ge PNP**	-hp-		
R1	0683-3945	32	R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945	
R2, R3	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635	

† Options 001, 003, 005, or 007

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A9, A10 (Cont'd)					
R4	0683-1045	67	R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R5, R6	0683-4735	107	R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R7, R8	0686-7525	54	R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525
R9	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R10, R11	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R12	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R13	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R14	0683-1815	27	R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815
R15	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R16	0683-3925	44	R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R17	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945
R18, R19	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R20	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R21, R22	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R23, R24	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525
R25	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R26, R27	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R28	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R29	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R30	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815
R31	0683-3325		R: fxd 3300 ohms 5% 1/4 W	01121	CB3325
R32	0683-3925		R: fxd 3900 ohms 5% 1/4 W	01121	CB3925
R33	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945
R34, R35	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R36	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R37, R38	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R39, R40	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525
R41	0683 2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R42, R43	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R44	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R45	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R46	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815
R47	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R48, R49	0683-3925		R: fxd comp 3900 ohms	01121	CB3925
R50	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945
R51, R52	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R53	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R54, R55	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R56, R57	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R58	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R59, R60	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	CB7525
R61	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R62, R63	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R64	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R65	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R66	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815
R67	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R68	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R69	0845-0001	6	Resistive network: 10 270 kilohms 2% 1/4 W	71590	obd
R70	0686-4735	6	R: fxd comp 47 kilohms 5% 1/2 W	01121	EB4735
V1	1990-0009	3	Plate: photoconductor matrix 4 line to 10 line conversion	-hp-	

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A11, A12 †	**03460-66511**	**2**	**Assembly: Reversible Counting Decade (1-2-2-4)**	**-hp-**		
A11A1, A12A1	03460-69503		Assembly: Nixie Decoding includes DS1A-H, R69, V1, and:	-hp-		
	0845-0001		Resistive network			
	0905-0043		Gasket: rubber	-hp-		
	0905-0051		Gasket: felt	-hp-		
	1990-0009		Plate: photoconductor	-hp-		
	2140-0044		Lamp: neon	-hp-		
	5040-4569		Socket: nixie	-hp-		
	5212A-83C		Cover column	-hp-		
	03440-63001		Block: photoconductor	-hp-		
	05212-0011		Shield: photo plate	-hp-		
C1, C2	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C3, C4	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300V	
C5, C6	0140-0218		C: fxd mica 160 pF 2%	04062	RDM15F161G3C	
C7, C8	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300V	
C9, C10	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C11, C12	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300V	
C13, C14	0140-0218		C: fxd mica 160 pF 2%	04062	RDM15F161G3C	
C15	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C16, C17	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300V	
C18	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
CR1, CR2	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR3 thru CR7	1901-0016		Diode: Ge 60 wiv	03877	S3185G	
CR8, CR9	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR10 thru CR16	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR17, CR18	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR19 thru CR24	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR25, CR26	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR27 thru CR33	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR34 thru CR36	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR37	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR38	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR39	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR40	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR41	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR42	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR43	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
DS1A thru DS1H	2140-0044		Lamp: neon	-hp-		
DS2	1970-0009		Tube: special purpose 10 digit numeral indicator	83594	B5991	obd
Q1 thru Q16	1850-0062		TSTR: Ge PNP**	-hp-		
R1	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945	
R2, R3	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635	
R4	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R5, R6	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R7, R8	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525	
R9	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R10, R11	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935	
R12	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R13	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R14	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815	

† Options 001, 003, 005, or 007

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A11, A12 (Cont'd)					
R15	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R16	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R17	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945
R18, R19	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R20	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R21, R22	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R23, R24	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525
R25	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R26, R27	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R28	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R29	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R30	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815
R31	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R32	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R33	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945
R34, R35	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R36	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R37, R38	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R39, R40	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525
R41	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R42, R43	0683-3935		R: comp 39 kilohms 5% 1/4 W	01121	CB3935
R44	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R45	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R46	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815
R47	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R48, R49	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R50	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945
R51, R52	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R53	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R54, R55	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R56, R57	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R58	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R59, R60	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525
R61	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R62, R63	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R64	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R65	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R66	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815
R67	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R68	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R69	0845-0001		Resistive network: 10 270 kilohms 2% 1/4 W	71590	obd
R70	0686-4735		R: fxd comp 47 kilohms 5% 1/2 W	01121	EB4735
R71	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R72, R73	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235
R74	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R75	0683-3035	20	R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035
R76	0683-1235	23	R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R77	0683-3335	31	R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335
R78	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R79, R80	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235
R81	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035
R82	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R83	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335
R84	0683-1835		R: fxd co mp 18 kilohms 5% 1/4 W	01121	CB1835
R85, R86	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235
R87	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035
R88	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R89	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335
R90	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R91, R92	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235
R93	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035
R94	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R95	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A11, A12 (Cont'd)						
V1	1990-0009		Plate: photoconductor matrix 4 line to 10 line conversion	-hp-		
A13 †	**03460-66513**	**1**	**Assembly: Reversible Counting Decade (1-2-2-4)**	**-hp-**		
A13A1	03460-69503		Assembly: Nixie Decoding includes DS1A-H, R97, V1, and:	-hp -hp-		
	0845-0001		Resistive network	71590	obd	
	0905-0043		Gasket: rubber	-hp-		
	0905-0051		Gasket: felt	-hp-		
	1990-0009		Plate: photoconductor	-hp-		
	2140-0044		Lamp: neon	-hp-		
	5040-4567		Socket: nixie	-hp-		
	5212A-83C		Cover column	-hp-		
	03440-63001		Block: photoconductor	-hp-		
	05212-0011		Shield: photo plate	-hp-		
C1, C2	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C3, C4	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300 V	
C5, C6	0140-0218		C: fxd mica 160 pF 2%	04062	RDM15F161G3C	
C7, C8	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300 V	
C9, C10	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C11, C12	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300 V	
C13, C14	0140-0218		C: fxd mica 160 pF 2%	04062	RDM15F161G3C	
C15	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C16, C17	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300 V	
C18	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C19, C20	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300 V	
CR1, CR2	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR3 thru CR7	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR8, CR9	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR10 thru CR16	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR17, CR18	19 01-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR19 thru CR24	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR25, CR26	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR27 thru CR34	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR35, CR36	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	
CR37 thru CR39	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR40, CR41	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR42, CR43	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR44 thru CR46	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR47	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR48	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	
CR49	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR50	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR51	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR52	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	
CR53	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR54	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	
CR55	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
DS1A thru DS1H	2140-0044		Lamp: neon	-hp-		
DS2	1970-0009		Tube: special purpose 10 digit numeral indicator	83594	B5991	obd

† Options 001, 003, 005, or 007

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A13 (Cont'd)					
Q1 thru Q27	1850-0062		TSTR: Ge PNP**	-hp-	
R1	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945
R2, R3	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R4	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R5, R6	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R7, R8	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525
R9	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R10, R11	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R12	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R13	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R14	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815
R15	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R16	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R17	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945
R18, R19	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R20	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R21	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R23, R24	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525
R25	0686-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	EB2735
R26, R27	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R28	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R29	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R30	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815
R31	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R32	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R33	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945
R34, R35	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R36	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R37, R38	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R39, R40	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525
R41	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R42, R43	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R44	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R45	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R46	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815
R47	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R48, R49	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R50	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945
R51, R52	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R53	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R54, R55	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R56, R57	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R58	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R59, R60	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525
R61	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R62, R63	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R64	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R65	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R66	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815
R67	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R68	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R69, R70	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R71†	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R72	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R73, R74	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525
R75, R76	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R77	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R78	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R79	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325

† A13R71 deleted at Serial No. 813-00451

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A13 (Cont'd)						
R80	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815	
R81	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R82	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R83	0683-1535	7	R: fxd comp 15 kilohms 5% 1/4 W	01121	CB1535	
R84	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R85	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525	
R86	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R87	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R88, R89	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945	
R90	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R91	0683-4715		R: fxd comp 470 ohms 5% 1/4 W	01121	CB4715	
R92	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	
R93	0683-6835		R: fxd comp 68 kilohms 5% 1/4 W	01121	CB6835	
R94	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R95	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935	
R96	0683-6835		R: fxd comp 68 kilohms 5% 1/4 W	01121	CB6835	
R97	0845-0001		Resistive network: 10 270 kilohms 2% 1/4 W	71590	obd	
R98 thru R106			Not assigned			
R107	0686-4735		R: fxd comp 47 kilohms 5% 1/2 W	01121	EB4735	
R108	0686-6825	6	R: fxd comp 6800 ohms 5% 1/2 W	01121	EB6825	
R109	0683-8225		R: fxd comp 8200 ohms 5% 1/4 W	01121	CB8225	
R110	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R111	0683-8225		R: fxd comp 8200 ohms 5% 1/4 W	01121	CB8225	
R112 thru R114	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R115	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	
R116	0758-0001	2	R: fxd prec met flm 3300 ohms 1% 1/2 W	19701	MF7C T-O	obd
R117, R118	0683-8225		R: fxd comp 8200 ohms 5% 1/4 W	01121	CB8225	
R119	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R120, R121	0683-8225		R: fxd comp 8200 ohms 5% 1/4 W	01121	CB8225	
R122	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R123	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R124, R125	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R126	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R127	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035	
R128	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	
R129	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R130	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R131, R132	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R133	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035	
R134	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R135	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	
R136	0686-6825		R: fxd comp 6800 ohms 5% 1/2 W	01121	EB6825	
R137	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R138, R139	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R140	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035	
R141	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R142	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	
R143	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R144	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R145, R146	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R147	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035	
R148	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R149	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	
R150	0757-0827	2	R: fxd prec met flm 2740 ohms 1% 1/2 W	19701	MF7C T-O	obd
R151	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R152, R153	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R154	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035	
R155	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R156	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A13 (Cont'd)					
V1	1990-0009		Plate: photoconductor matrix 4 line to 10 line conversion	-hp-	
A14	**03460-66514**	**1**	**Assembly: Timing and Control**	**-hp-**	
C1	0140-0149	2	C: fxd mica 470 pF 5% 300 vdcw	04062	DM15F471J
C2			Deleted at Serial No. 732-00251		
	0140-0198		C: fxd mica 200 pF 5% above Serial No. 709-00176	04062	RDM15F201J3C
	0140-0149		C: fxd mica 470 pF 5% below Serial No. 709-00176	04062	DM15F471J
C3	0140-0152		C: fxd mica 1000 pF 5% 300 vdcw	04062	DM16F102J
C4	0180-0105		C: fxd Al elect 50 μF +100% -10% 25 vdcw	56289	D34114
C5	0140-0151		C: fxd mica 820 pF 2% 300 vdcw	04062	RDM15F821G3C
C6	0140-0207	5	C: fxd mica 330 pF 5% 500 vdcw	04062	RDM15F331J5C
C7	0160-0155	7	C: fxd 0.0033 μF 10% 200 vdcw	56289	192P33292
C8	0160-0163	1	C: fxd 0.033 μF 10%	56289	192P33392
C9	0180-0216		C: fxd Ta elect 12 μF 10% 35 vdcw	56289	150D126X9035R2-DYS
C10	0140-0149		C: fxd mica 470 pF 5% 300 vdcw	04062	DM15F471J
C11			Deleted at Serial No. 732-00251		
			C: fxd mica 330 pF 5% 500 vdcw	72136	
C12	0160-0194	2	C: fxd 0.015 μF 10% 200 vdcw	56289	192P15392
C13	0150-0121		C: fxd cer 0.1 μF +80% -20% 50 vdcw	56289	5C50A obd
C14	0140-0151		C: fxd mica 820 pF 2% 300 vdcw	04062	RDM15F821G3C
C15	0140-0207		C: fxd mica 330 pF 5% 500 vdcw	04062	RDM15F331J5C
C16	0170-0038	1	C: fxd my 0.22 μF 10% 200 vdcw	56289	148P22492
C17	0140-0151		C: fxd mica 820 pF 2% 300 vdcw	04062	RDM15F821G3C
C18	0170-0051	2	C: fxd my 0.635 μF 5% 100 vdcw	01281	HEW 17 obd
C19	0140-0152		C: fxd mica 1000 pF 5% 300 vdcw	04062	DM16F102J
C20	0160-0155		C: fxd 0.0033 μF 10% 200 vdcw	56289	192P33292
C21, C22	0140-0207		C: fxd mica 330 pF 5% 500 vdcw	04062	RDM15F331J5C
C23	0140-0150	1	C: fxd mica 731.5 pF 1%	04062	RDM15F(731.5)F3S
C24	0160-0155		C: fxd 0.0033 μF 10% 200 vdcw	56289	192P33292
C25	0150-0121		C: fxd cer 0.1 μF +80% -20% 50 vdcw	56289	5C50A obd
C26			Not assigned		
C27	0140-0207		C: fxd mica 330 pF 5% 500 vdcw	04062	RDM15F331J5C
C28	0170-0051		C: fxd my 0.635 μF 5% 100 vdcw	01281	HEW 17 obd
C29, C30	0180-0367	2	C: fxd Al elect 20 μF +75% -10% 200 vdcw	56289	34D206G200FJ4
C31 thru C34	0140-0151		C: fxd mica 820 pF 1% 300 vdcw	04062	RDM15F821G3C
CR1	1901-0081	77	Diode: Si 50 wiv 10 ns 6 pF	82647	obd
CR2	1902-0025	1	Diode: breakdown 10.0 V 5% 400 mw	04713	SZ10939-182
CR3	1901-0033	12	Diode: Si 100 mA at +1 V 180 wiv IN485B	93332	D6238 obd
CR4 thru CR7	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072 obd
CR8	1901-0033		Diode: Si 100 mA at +1 V 180 wiv IN485B	93332	D6238 obd
CR9, CR10	1910-0016		Diode: Ge 60 wiv	03877	S3185G
CR11 thru CR16	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072 obd
CR17	1901-0049	2	Diode: breakdown 6.19 V 5% 400 mW	04713	SZ10939-122
CR18, CR19	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072 obd
CR20	1901-0033		Diode: Si 100 mA at +1 V 180 wiv IN485B	93332	D6238 obd
CR21	1910-0016		Diode: Ge 60 wiv	03877	S3185G
CR22, CR23	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072 obd
CR24	1910-0016		Diode: Ge 60 wiv	03877	S3185G
CR25 thru CR30	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072 obd
CR31			Not assigned		
CR32	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072 obd

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A14 (Cont'd)						
CR33	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR34	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR35, CR36	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR37, CR38	1901-0044	2	Diode: Si 50 mA at +1 V 10 na reverse current 50 wiv 2 pF	07910	obd	
CR39 thru CR41	1901-0033		Diode: Si 100 mA at +1 V 180 wiv IN485B	93332	D6238	obd
CR42 thru CR57	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR58	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR59, CR60	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR61	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR62, CR63	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
Q1, Q2	1850-0062		TSTR: Ge PNP**	-hp-		
Q3	1851-0017	3	TSTR: Ge NPN 2N1304	01295	2N1304	
Q4	1850-0111	8	TSTR: Ge PNP 2N404A	01295	2N404A	
Q5 thru Q12	1850-0062		TSTR: Ge PNP**	-hp-		
Q13	1850-0040		TSTR: Ge PNP**	-hp-		
Q14	1854-0022	8	TSTR: Si NPN**	-hp-		
Q15	1851-0017		TSTR: Ge NPN 2N1304	01295	2N1304	
Q16 thru Q19	1850-0062		TSTR: Ge PNP**	-hp-		
Q20	1850-0111		TSTR: Ge PNP 2N404A	01295	2N404A	
Q21	1850-0062		TSTR: Ge PNP**	-hp-		
Q22	1851-0017		TSTR: Ge NPN 2N1304	01295	2N1304	
Q23	1854-0003		TSTR: Si NPN**	-hp-		
R1	0683-2025		R: fxd comp 2000 ohms 5% 1/4 W	01121	CB2025	
R2	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R3	0683-5135		R: fxd comp 51 kilohms 5% 1/4 W	01121	CB5135	
R4	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925	
R5	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	
R6, R7	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R8	0683-5135		R: fxd comp 51 kilohms 5% 1/4 W	01121	CB5135	
R9	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R10	0683-1225	1	R: fxd comp 1200 ohms 5% 1/4 W	01121	CB1225	
R11	0683-6235	1	R: fxd comp 62 kilohms 5% 1/4 W	01121	CB6235	
R12	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R13	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R14	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R15	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R16	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R17	0683-1335	1	R: fxd comp 13 kilohms 5% 1/4 W above Serial No. 732-00401	01121	CB1335	
	0683-1135	1	R: fxd comp 11 kilohms 5% 1/4 W below Serial No. 732-00401	01121	CB1135	
R18	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R19	0683-4725	5	R: fxd comp 4700 ohms 5% 1/4 W	01121	CB4725	
R20 thru R22	0683-2035	6	R: fxd comp 20 kilohms 5% 1/4 W	01121	CB2035	
R23	0683-2245	6	R: fxd comp 220 kilohms 5% kilohms 5% 1/4 W	01121	CB2245	
R24	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB2245	
R25	0683-5135		R: fxd comp 51 kilohms 5% 1/4 W	01121	CB5135	
R26	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925	
R27	0757-0967	1	R: fxd met flm 62 kilohms 2% 1/8 W	19701	MF07C	obd
R28	0686-1035	4	R: fxd comp 10 kilohms 5% 1/2 W	01121	EB1035	
R29	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R30	0757-0956		R: fxd met flm 22 kilohms 2% 1/8 W	19701	MF07C	obd
R31	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925	
R32	0683-5135		R: fxd comp 51 kilohms 5% 1/4 W	01121	CB5135	
R33	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R34	0757-0962		R: fxd met flm 39 kilohms 2% 1/8 W	19701	MF07C	obd
R35	0683-1025	6	R: fxd comp 1000 ohms 5% 1/4 W	01121	CB1025	

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A14 (Cont'd)					
R36	0683-5135		R: fxd comp 51 kilohms 5% 1/4 W	01121	CB5135
R37	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R38	0686-4725	2	R: fxd comp 4700 ohms 5% 1/2 W	01121	EB4725
R39	0686-8225	2	R: fxd comp 8200 ohms 5% 1/2 W	01121	EB8225
R40	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335
R41	0686-6225	3	R: fxd comp 6200 ohms 5% 1/2 W	01121	EB6225
R42			Not assigned		
R43	0683-5135		R: fxd comp 51 kilohms 5% 1/4 W	01121	CB5135
R44	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R45	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235
R46	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R47	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235
R48	0686-6225		R: fxd comp 6200 ohms 5% 1/2 W	01121	EB6225
R49	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R50			Not assigned		
R51	0683-5135		R: fxd comp 51 kilohms 5% 1/4 W	01121	CB5135
R52	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R53	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R54	0683-2745	5	R: fxd comp 270 kilohms 5% 1/4 W	01121	CB2745
R55	0686-3325		R: fxd comp 3300 ohms 5% 1/2 W	01121	EB3325
R56	0686-6835		R: fxd comp 68 kilohms 5% 1/2 W	01121	EB6835
R57	0683-8235	2	R: fxd comp 82 kilohms 5% 1/4 W	01121	CB8235
R58	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R59	0683-2215	1	R: fxd comp 220 ohms 5% 1/4 W	01121	CB2215
R60	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R61	0683-3345	1	R: fxd comp 330 kilohms 5% 1/4 W	01121	CB3345
R62	0683-2245		R: fxd comp 220 kilohms 5% 1/4 W	01121	CB2245
R63	0683-1245	3	R: fxd comp 120 kilohms 5% 1/4 W	01121	CB1245
R64	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R65	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R66	0686-1035		R: fxd comp 10 kilohms 5% 1/2 W	01121	EB1035
R67, R68	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R69	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815
R70	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R71	0686-1035		R: fxd comp 10 kilohms 5% 1/2 W	01121	EB1035
R72	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R73	0683-1535		R: fxd comp 15 kilohms 5% 1/4 W	01121	CB1535
R74	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R75	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R76	0686-4725		R: fxd comp 4700 ohms 5% 1/2 W	01121	EB4725
R77, R78	0683-2435	2	R: fxd comp 24 kilohms 5% 1/4 W	01121	CB2435
R79, R80	0683-3625	2	R: fxd comp 3600 ohms 5% 1/4 W	01121	CB3625
R81	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235
R82	0686-6225		R: fxd comp 6200 ohms 5% 1/2 W	01121	EB6225
R83			Not assigned		
R84	0683-5135		R: fxd comp 51 kilohms 5% 1/4 W	01121	CB5135
R85	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R86, R87	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R88	0683-6835		R: fxd comp 68 kilohms 5% 1/4 W	01121	CB6835
R89	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R90	0683-1535		R: fxd comp 15 kilohms 5% 1/4 W	01121	CB1535
R91	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235
R92	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335
R93			Not assigned		
R94	0683-5135		R: fxd comp 51 kilohms 5% 1/4 W	01121	CB5135
R95, R96	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R97	0683-4745	1	R: fxd comp 470 kilohms 5% 1/4 W	01121	CB4745
R98	0683-4725		R: fxd comp 4700 ohms 5% 1/4 W	01121	CB4725
R99	0683-1015	2	R: fxd comp 100 ohms 5% 1/4 W	01121	CB1015
R100	0683-1025		R: fxd comp 1000 ohms 5% 1/4 W	01121	CB1025

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A14 (Cont'd)						
R101	0683-2245		R: fxd comp 220 kilohms 5% 1/4 W	01121	CB2245	
R102	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R103, R104	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R105, R106	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R107, R108	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R109	0683-2245		R: fxd comp 220 kilohms 5% 1/4 W	01121	CB2245	
R110, R111	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	
R112	0683-2245		R: fxd comp 220 kilohms 5% 1/4 W	01121	CB2245	
R113 thru R117			Not assigned			
R118	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R119	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935	
R120	0683-1735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R121	0683-5105	1	R: fxd comp 50 ohms 5% 1/4 W	01121	CB5105	
A15			**Not assigned**			
A16	**03460-66516**	**1**	**Assembly: Counter Driver**	**-hp-**		
C1	0140-0215	1	C: fxd mica 80 pF 2% 300 vdcw	04062	RDM15E800G3C	
C2 thru C4	0160-0155		C: fxd 0.0033 microfarads 10% 200 vdcw	56289	192P33292C5, C6	
C5, C6	0140-0197	2	C: fxd mica 180 pF 5%	04062	RDM15F181J3C	
C7, C8	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C9 thru C12	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300V	
C13, C14	0140-0178	2	C: fxd mica 560 pF 2% 300 vdcw	04062	RDM15F561G3C	
C15	0140-0177	1	C: fxd mica 400 pF 1% 300 vdcw	04062	RDM15F401F3C	
C16	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300V	
C17 thru C19	0150-0121		C: fxd cer 0.1 microfarads +80% -20% 50 vdcw	56289	5C50A	obd
C20	0160-0155		C: fxd 0.0033 microfarads 10% 200 vdcw	56289	192P33292	
CR1, CR2	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR3	1902-0049		Diode: breakdown 6.19 V 5% 400 mW	04713	SZ10939 122	
CR4 thru CR28	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR29 thru CR31	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR32	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
Q1, Q2	1850-0062		TSTR: Ge PNP**	-hp-		
Q3 thru Q6	1850--0111		TSTR: Ge PNP 2N404A	01295	2N404A	
Q7, Q8	1854-0003		TSTR: Si NPN**	-hp-		
Q9, Q10	1850-0062		TSTR: Ge PNP**	-hp-		
Q11, Q12	1850-0111		TSTR: Ge PNP 2N404A	01295	2N404A	
Q13 thru Q21	1850-0062		TSTR: Ge PNP**	-hp-		
R1, R2	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R3	0683-6825	2	R: fxd comp 6800 ohms 5% 1/4 W	01121	CB6825	
R4	0683-1015		R: fxd comp 100 ohms 5% 1/4 W	01121	CB1015	
R5	0683-6825		R: fxd comp 6800 ohms 5% 1/4 W	01121	CB6825	
R6, R7	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R8			Not assigned			
R9, R10	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635	
R11	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	
R12	0683-1525	2	R: fxd comp 1500 ohms 5% 1/4 W	01121	CB1525	
R13, R14	0686-5625	2	R: fxd comp 5600 ohms 5% 1/2 W	01121	EB5625	
R15	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935	

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A16 (Cont'd)					
R16	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R17, R18	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R19	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R20	0683-1525		R: fxd comp 1500 ohms 5% 1/4 W	01121	CB1525
R21	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335
R22	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R23	0683-5625		R: fxd comp 5600 ohms 5% 1/4 W	01121	CB5625
R24, R25	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R26	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R27	0683-5625		R: fxd comp 5600 ohms 5% 1/4 W	01121	CB5625
R28	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R29	0683-2025		R: fxd comp 2000 ohms 5% 1/4 W	01121	CB2025
R30, R31	0683-1535		R: fxd comp 15 kilohms 5% 1/4 W	01121	CB1535
R32	0683-1245		R: fxd comp 120 kilohms 5% 1/4 W	01121	CB1245
R33	0683-2025		R: fxd comp 2000 ohms 5% 1/4 W	01121	CB2025
R34	0683-1245		R: fxd comp 120 kilohms 5% 1/4 W	01121	CB1245
R35, R36	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R37	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R38, R39	0683-3925	2	R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R40	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R41	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035
R42	0683-1535		R: fxd comp 15 kilohms 5% 1/4 W	01121	CB1535
R43 thru R46	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R47	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R48, R49	0683-6835		R: fxd comp 68 kilohms 5% 1/4 W	01121	CB6835
R50	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R51, R52	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R53	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R54	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R55, R56	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R57	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R58	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R59	0686-1045	2	R: fxd comp 100 kilohms 5% 1/2 W	01121	EB1045
R60, R61	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R62	0686-1045		R: fxd comp 100 kilohms 5% 1/2 W	01121	EB1045
R63	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R64	0683-2725	1	R: fxd comp 2700 ohms 5% 1/4 W	01121	CB2725
R65	0686-2245	1	R: fxd comp 220 kilohms 5% 1/2 W	01121	EB2245
R66, R67	0683-1025		R: fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
R68, R69	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R70	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335
R71, R72	0686-1235	3	R: fxd comp 12 kilohms 5% 1/2 W	01121	EB1235
R73 thru R75	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335
R76, R77	0683-4725		R: fxd comp 4700 ohms 5% 1/4 W	01121	CB4725
R78	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R79	0683-1535		R: fxd comp 15 kilohms 5% 1/4 W	01121	CB1535
R80	0683-4725		R: fxd comp 4700 ohms 5% 1/4 W	01121	CB4725
R81	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R82	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R83	0686-6825		R: fxd comp 6800 ohms 5% 1/2 W	01121	EB6825
R84	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R85	0686-6825		R: fxd comp 6800 ohms 5% 1/2 W	01121	EB6825
R86	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R87	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035
R88	2100-0093	1	R: var pot comp lin 20 kilohms 20 % 1/5 W	71450	UPE7ORE(-hp-) obd
R89	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R90	0683-1025		R: fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
R91	0683-6835		R: fxd comp 68 kilohms 5% 1/4 W	01121	CB6835
R92	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R93, R94	0686-5125	2	R: fxd comp 5100 ohms 5% 1/2 W	01121	EB5125
R95	0683-6835		R: fxd comp 68 kilohms 5% 1/4 W	01121	CB6835

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A16 (Cont'd)						
R96, R97	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R98, R99	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R100, R101	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
A17	**03460-66517**	**1**	**Assembly: Sample Period Generator**	**-hp-**		
C1, C2	0140-0198		C: fxd mica 200 pF 5% 300 vdcw	04062	RDM15F201J3C	
C3	0160-0989	1	C: fxd poly 1.2 microfarads 5%	-hp-		
C4	0160-0168	1	C: fxd 0.1 microfarads 10% 200 vdcw	56289	192P10492	
CR1	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR2, CR3	1901-0033		Diode: Si 100 mA at +1 V 180 wiv IN485B	93332	D6238	obd
CR4	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR5, CR6	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR7 thru CR9	1901-0033		Diode: Si 100 mA at +1 V 180 wiv IN485B	93332	D6238	obd
CR10, CR11	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR12	1901-0033		Diode: Si 100 mA at +1 V 180 wiv IN485B	93332	D6238	obd
CR13, CR14	1902-0037	2	Diode: breakdown 9.1 V 10% 400 mW	01281	PS18256	
K1	0490-0327	1	Relay: reed miniature form A	-hp-		
L1	9100-0362	1	Coil: electromagnetic wound on nylon bobbin	71707	U 24 P	obd
Q1, Q2	1850-0062		TSTR: Ge PNP**	-hp-		
Q3	1854-0067	1	TSTR: Si NPN 2N2102	86684	2N2102	
Q4	1854-0221		TSTR: Si NPN dual**	-hp-		
Q5, Q6	1854-0033		TSTR: Si NPN 2N3391	24446	2N3391	
Q7	1850-0062		TSTR: Ge PNP**	-hp-		
R1	0686-8225		R: fxd comp 8200 ohms 5% 1/2 W	01121	EB8225	
R2	0686-3335	2	R: fxd comp 33 kilohms 5% 1/2 W	01121	EB3335	
R3	0686-3935	1	R: fxd comp 39 kilohms 5% 1/2 W	01121	EB3935	
R4	0686-4735		R: fxd comp 47 kilohms 5% 1/2 W	01121	EB4735	
R5	0686-2735	2	R: fxd comp 27 kilohms 5% 1/2 W	01121	EB2735	
R6	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R7	0686-1035		R: fxd comp 10 kilohms 5% 1/2 W	01121	EB1035	
R8 thru R11	0686-4735		R: fxd comp 47 kilohms 5% 1/2 W	01121	EB4735	
R12	0686-2735		R: fxd comp 27 kilohms 5% 1/2 W	01121	EB2735	
R13	0686-4335	2	R: fxd comp 43 kilohms 5% 1/2 W	01121	EB4335	
R14	0686-3935	1	R: fxd comp 39 kilohms 5% 1/2 W	01121	EB3935	
R15	0686-2235	1	R: fxd comp 22 kilohms 5% 1/2 W	01121	EB2235	
R16	0686-4335		R: fxd comp 43 kilohms 5% 1/2 W	01121	EB4335	
R17	0686-6825		R: fxd comp 6800 ohms 5% 1/2 W	01121	EB6825	
R18	0757-0746		R: fxd prec met flm 4750 ohms 1% 1/4 W	75042	CEB T-O	obd
R19	0686-3335		R: fxd comp 33 kilohms 5% 1/2 W	01121	EB3335	
R20			Not assigned			
R21	0811-1358	1	R: fxd prec ww 235.2 kilohms 0.025% 1/4 W	-hp-		
R22	0811-1361	1	R: fxd prec ww 9800 ohms 0.025% 1/8 W	-hp-		
R23	0757-0782	4	R: fxd prec met flm 200 kilohms 1% 1/4 W	19701	MF6C T-O	obd
R24	0811-1363	1	R: fxd prec ww 49 kilohms 0.025% 1/4 W	-hp-		
R25	0757-0782		R: fxd prec met flm 200 kilohms 1% 1/4 W	19701	MF6C T-O	obd
R26	0757-0342		R: fxd prec met flm 100 kilohms 1% 1/4 W	75042	CEB T-O	obd

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A17 (Cont'd)					
R27	0757-0754	1	R: fxd prec met flm 11.0 kilohms 1% 1/4 W	19701	MF6C T-O obd
R28	0757-0782		R: fxd prec met flm 200 kilohms 1% 1/4 W	19701	MF6C T-O obd
R29	0811-1105	2	R: set matched fxd prec ww (includes R29,R31)	-hp-	
R30	2100-1483		R: var ww lin 200 ohms 5% 3/4 W	12697	76JA3 CM32466
R31	0811-1105		R: set matched fxd prec ww	-hp-	
R32, R33	0757-0782		R: fxd prec met flm 200 kilohms 1% 1/4 W	19701	MF6C T-O obd
R34	0757-0821	1	R: fxd prec met flm 1210 ohms 1% 1/2 W	19701	MF7C T-O obd
A18	**03460-66518**	**1**	**Assembly: Main Power Supply**	**-hp-**	
C1	0180-0094		C: fxd Al elect 100 microfarads +100% -10% 25 vdcw	56289	30D107G025DH4
C2	0180-0050		C: fxd Al elect 40 microfarads +100% -15% 50 vdcw	56289	D32538
C3	0180-0094	1	C: fxd 100 microfarads +75% -10% 25 vdcw above Serial No. 709-00176	56289	30D107G025DD2-DSM
	0180-0105		C: fxd Al elect 50 microfarads +100% -10% 25 vdcw below Serial No. 709-00176	56289	D34114
CR1 thru CR4	1901-0026		Diode: Si 200 piv	04713	obd
CR5	1902-3181	1	Diode: Si breakdown 12.1 V 10% 400 mW	01281	PS18268
CR6 thru CR9	1901-0026		Diode: Si 200 piv	04713	obd
CR10 thru CR13	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072 obd
CR14 thru CR17	1901-0028	4	Diode: Si 400 piv	04713	obd
Q1 thru Q3	1850-0062		TSTR: Ge PNP**	-hp-	
Q4	1850-0090	1	TSTR: Ge PNP 2N1183B	86684	2N1183B
Q5	1854-0039	1	TSTR: Si NPN 2N3053	86684	2N3053
Q6	1854-0029	1	TSTR: Si NPN 2N2712	24446	obd
R1	0761-0061	1	R: fxd met oxide flm 1300 ohms 5% 1 W	07115	C32 obd
R2	0686-1535	1	R: fxd comp 15 kilohms 5% 1/2 W	01121	EB1535
R3	0813-0028	2	R: fxd ww 1 ohm 10% 1 W	00213	1000S obd
R4	0757-0397	2	R: fxd prec met flm 68.1 ohms 1% 1/8 W	19701	MF5C T-O obd
R5	0757-0740	2	R: fxd prec met flm 2210 ohms 1% 1/4 W	19701	MF6C T-O obd
R6	0683-1025		R: fxd comp 1000 ohms 5% 1/4 W	01121	CB1025
R7	0757-0404	1	R: fxd prec met flm 130 ohms 1% 1/8 W above Serial No. 706-01096	19701	MF5C T-O obd
	0757-1102	1	R: fxd prec met flm 180 ohms 1% 1/8 W below Serial No. 706-01096	19701	MF5C T-O obd
R8	2100-0281	1	R: var ww 100 ohms 20% 1-1/2 W	71450	110 obd
R9	0757-0727	1	R: fxd prec met flm 562 ohms 1% 1/4 W	19701	MF6C T-O obd
R10	0811-1338	1	R: fxd prec ww 8200 ohms 1% 5 W	00213	1500S
R11	0686-1835	1	R: fxd comp 18 kilohms 5% 1/2 W	01121	EB1835
R12	0813-0028		R: fxd ww 1 ohm 10% 1 W	00213	1000S
R13	0757-0397		R: fxd prec met flm 68.1 ohms 1% 1/8 W	19701	MF5C T-O obd
R14	0757-0745	1	R: fxd prec met flm 4320 ohms 1% 1/4 W	75042	CEB T-O obd
R15	0757-0734	1	R: fxd prec met flm 1210 ohms 1% 1/4 W	19701	MF6C T-O obd
R16	0698-3282	1	R: fxd prec met flm 1180 ohms 1% 1/4 W	19701	MF6C T-O obd
R17	0686-1525	1	R: fxd comp 1500 ohms 5% 1/2 W	01121	EB1525
R18	0686-1825	2	R: fxd comp 1800 ohms 5% 1/2 W	01121	EB1825
R19	0683-4315	11	R: fxd comp 430 ohms 5% 1/4 W	01121	CB4315
R20	0686-1825		R: fxd comp 1800 ohms 5% 1/2 W	01121	EB1825
R21	0683-1005	1	R: fxd comp 10 ohms 5% 1/4 W	01121	CB1005
R22	0698-3279	1	R: fxd comp met mlm 4990 ohms 1% 1/8 W	19701	MF5C T-O obd

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A18 (Cont'd)						
R23	0698-3283	1	R: fxd prec met flm 9310 ohms 1% 1/4 W	19701	MF6C T-O	obd
R24, R25	0687-4701	2	R: fxd comp 47 ohms 10% 1/2 W	01121	EB4701	
A19	**03460-66901**	**1**	**Assembly: Reference Power Supply**	**-hp-**		
			NOTE Reference power supply includes the mounted chassis, A19A1, A19A2, complete oven assembly, C1, C2, J18, J19, and J25. Indicate reference supply voltage (13.960 or 13.300) when ordering replacement.			
A1	03460-66507	1	Assembly: Oven Controlled Power Supply	-hp-		
A1C1	0170-0055	1	C: fxd 0.1 microfarads 20% 200 vdcw	56289	192P10402A	
A1C2	0160-0194		C: fxd 0.015 microfarads 10% 200 vdcw	56289	192P15392	
A1CR1 thru CR4	1901-0045		Diode: Si 100 piv	04713	obd	
A1CR5 thru CR9	1901-0049	5	Diode: Si 50 piv	04713	obd	
A1CR10	1902-0401	1	Diode: Si breakdown 26.7 V 5% 1-1/2 W	04713	obd	
A1CR11	1902-0048	1	Diode: breakdown 6.81V 5% 400 mW	07910	CD35658	
A1Q1	1850-0064	1	TSTR: Ge PNP 2N1183	86684	2N1183	
A1Q2, Q3	1854-0033		TSTR: Si NPN 2N3391	24446	2N3391	
A1R1	0811-0920	1	R: prec ww 1200 ohms 3% 3 W	63743	3SX	obd
A1R2	0757-0159	1	R: fxd prec met flm 1000 kilohms 1% 1/2 W	75042	CEB T-O	obd
A1R3	0811-1356	1	R: prec ww 8 ohms 5% 1/4 W	-hp-		
A1R4	0811-1350	1	R: prec ww 16 ohms 5% 1/4 W	-hp-		
A1R5	0811-1352	1	R: prec ww 32 ohms 2% 1/4 W	-hp-		
A1R6	0811-1348	1	R: prec ww 64 ohms 1.0% 1 W	-hp-		
A1R7	0811-1347	1	R: prec ww 128 ohms 0.4% 1/2 W	-hp-		
A1R8	2100-1485	5	R: var ww lin 20 kilohms 5% 3/4 W	12697	76JA3 CM32591	
A1R9	0811-1355	1	R: prec ww 80 kilohms 1.0% 1/4 W	-hp-		
A1R10	0757-0464	1	R: fxd met flm 90.0 kilohms 1% 1/8 W	75042	CEA T-O	obd
A1R11	0811-0227	1	R: fxd ww 800 ohms 1% 3 W	00213	1200P	obd
A1R12	0757-0736	1	R: fxd prec met flm 1500 ohms 1% 1/4 W	19701	MF6C T-O	obd
A1R13, R14	0757-0465	1	R: fxd prec met flm 100 kilohms 1% 1/8 W	19701	MF5C T-O	obd
A1R15	0811-1349	1	R: prec ww 930 ohms 0.1% 1/2 W	-hp-		
A1R16	0811-1351	1	R: prec ww 90 ohms 1.0% 1/4 W	-hp-		
A1R17	0811-1346	1	R: fxd prec ww 256 ohms 0.2% 1/2 W	-hp-		
A2	03460-66901	1	Assembly: Control (in oven). Not separately replaceable.	-hp-		
C1	0180-0382	1	C: fxd Al elect 500 microfarads +75% -10% 75 vdcw	56289	D39F92 6439	
C2	0180-0384	2	C: fxd Al elect 1500 microfarads +100% -10% 40 vdcw	56289	D39590 6439	
F1	2110-0069	1	Fuse: thermal (87°C 5°C)	71400	TGW	obd

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A19 (Cont'd)					
S1	0440-0006	1	Thermostat: Mercury	18509	obd
A20	**03460-66520**	**1**	**Assembly: Trigger Input**	**-hp-**	
C1 thru C3	0160-0161		C: fxd 0.01 microfarads 10% 200 vdcw	56289	192P10392
CR1	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072 obd
R1	0687-2231	2	R: fxd comp 22 kilohms 10% 1/2 W	01121	EB2231
R2	0687-4731	1	R: fxd comp 47 kilohms 10% 1/2 W	01121	EB4731
R3	0687-2231		R: fxd comp 22 kilohms 10% 1/2 W	01121	EB2231
R4	0687-1031	1	R: fxd comp 10 kilohms 10% 1/2 W	01121	EB1031
R5	0758-0023	1	R: fxd 240 ohms 5% 1/2 W	07115	obd
R6	0687-2721	1	R: fxd comp 2700 ohms 10% 1/2 W	01121	EB2721
A21	**03460-61901**	**1**	**Assembly: Digital-to-Analog Relay**	**-hp-**	
CR1 thru CR14	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072 obd
K1 thru K14	0490-0151	14	Relay: dry reed switch	-hp-	
L1 thru L14	9100-0352	14	Coil: electromagnetic	71707	obd
R1 thru R14	0683-4315	14	R: fxd comp 430 ohms 5% 1/4 W	01121	CB4315
A22 thru A30			**Not assigned**		
A31, A32 †	**03460-66531**	**2**	**Assembly: Reversible Counting Decade (1-2-4-8)**	**-hp-**	
A31A1, A32A1	03460-69502		Assembly: Nixie Decoding includes DS1A-H, R69, V1, and:	-hp-	
	0845-0001		Resistive network	71590	obd
	0905-0043		Gasket: rubber	-hp-	
	0905-0051		Gasket: felt	-hp-	
	1990-0018		Plate: photoconductor	-hp-	
	2140-0044		Lamp: neon	-hp-	
	5040-4569		Socket: nixie	-hp-	
	5212A-83C		Cover: column	-hp-	

† Std. Opt. 002, 004, or 006

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A31, A32 (Cont'd)						
	03440-63001		Block: photoconductor	-hp-		
	05212-0011		Shield: photo plate	-hp-		
C1, C2	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C3, C4	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300V	
C5, C6	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C7, C8	0140-0193	6	C: fxd mica 82 pF 5%	04062	RDM15E820J3C	
C9, C10	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C11, C12	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300F	
C13, C14	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C15, C16	0140-0198		C: fxd mica 200 pF 5% 300 vdcw	04062	RDM15F201J3C	
C17	0140-0218		C: fxd mica 160 pF 2%	04062	RDM15F161G3C	
C18	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
CR1, CR2	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR3 thru CR7	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR8, CR9	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR10 thru CR16	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR17, CR18	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR19 thru CR24	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR25, CR26	1901-0025		Diode: Si 100 mA at +1 V 200 piv 12 pF	93332	D3072	obd
CR27 thru CR33	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
DS1A thru DS1H	2140-0044		Lamp: neon	-hp-		
DS2	1970-0009		Tube: special purpose 10 digit numeral indicator	83594	B5991	
Q1 thru Q8	1850-0062		TSTR: Ge PNP**	-hp-		
R1	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945	
R2, R3	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635	
R4	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R5, R6	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R7, R8	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525	
R9	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R10, R11	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935	
R12	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R13	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R14	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815	
R15	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R16	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925	
R17	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945	
R18, R19	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635	
R20	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R21, R22	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R23, R24	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525	
R25	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R26, R27	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935	
R28	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R29	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R30	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815	
R31	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R32	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925	
R33	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945	
R34, R35	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635	
R36	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A31, A32 (Cont'd)						
R37, R38	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R39, R40	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525	
R41	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R42, R43	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935	
R44	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R45	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R46	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815	
R47	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R48	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925	
R49	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945	
R50, R51	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635	
R52	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R53	0683-2035		R: fxd comp 20 kilohms 5% 1/4 W	01121	CB2035	
R54	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R55, R56	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525	
R57	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R58, R59	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935	
R60	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R61	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R62	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815	
R63	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R64	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925	
R65, R66	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R67, R68	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925	
R69	0845-0001		Resistive network: 10-270 kilohms 2% 1/4 W	71590	obd	
R70	0686-4735		R: fxd comp 47 kilohms 5% 1/2 W	01121	EB4735	
V1	1990-0018	3	Plate: photoconductor matrix 4 line to 10 line conversion	-hp-		
A33, A34 †	**03460-66533**	**2**	**Assembly: Reversible Counting Decade**	**-hp-**		
A33A1, A34A1	03460-69502		SAME AS A31A1, A32A1			
C1, C2	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C3, C4	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300V	
C5, C6	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C7, C8	0140-0193		C: fxd mica 82 pF 5%	04062	RDM15E820J3C	
C9, C10	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C11, C12	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300V	
C13, C14	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C15, C16	0140-0198		C: fxd mica 200 pF 5% 300 vdcw	04062	RDM15F201J3C	
C17	0140-0218		C: fxd mica 160 pF 2%	04062	RDM15F161G3C	
C18	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
CR1, CR2	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR3 thru CR7	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR8, CR9	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR10 thru CR16	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR17, CR18	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR19 thru CR24	1901-0016		Diode: Ge 60 wiv	03877	S3185G	
CR25, CR26	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR27 thru CR33	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR34 thru CR36	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR37	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR38	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR39	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR40	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR41	1910-0016		Diode: Ge 60 wiv	03877	S3185G	

† Std, Opt. 002, 004, or 006

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A33, A34 (Cont'd)					
CR42	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072 obd
CR43	1910-0016		Diode: Ge 60 wiv	03877	S3185G
DS1A-H	2140-0044		Lamp: neon	-hp-	
DS2	1970-0009		Tube: special purpose 10 digit numeral indicator	83594	B5991 obd
Q1 thru Q16	1850-0062		TSTR: Ge PNP**	-hp-	
R1	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945
R2, R3	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R4	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R5, R6	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R7, R8	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525
R9	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R10, R11	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R12	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R13	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R14	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815
R15	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R16	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R17	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945
R18, R19	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R20	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R21, R22	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R23, R24	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525
R25	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R26, R27	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R28	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R29	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R30	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815
R31	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R32	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R33	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945
R34, R35	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R36	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R37, R38	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R39, R40	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525
R41	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R42, R43	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R44	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R45	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R46	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815
R47	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R48	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R49	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945
R50, R51	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635
R52	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R53	0683-2035		R: fxd comp 20 kilohms 5% 1/4 W	01121	CB2035
R54	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235
R55, R56	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525
R57	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
R58, R59	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935
R60	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R61	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R62	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815
R63	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325
R64	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925
R65, R66	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A33, A34 (Cont'd)						
R67, R68	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925	
R69	0845-0001		Resistive network: 10-270 kilohms 2% 1/4 W	71590	obd	
R70	0686-4735		R: fxd comp 47 kilohms 5% 1/2 W	01121	EB4735	
R71	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R72, R73	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R74	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R75	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035	
R76	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R77	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	
R78	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R79, R80	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R81	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035	
R82	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R83	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	
R84	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R85, R86	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R87	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035	
R88	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R89	0683-3335		R: fxd comp 33 kikohms 5% 1/4 W	01121	CB3335	
R90	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R91, R92	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R93	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035	
R94	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R95	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	
V1	1990-0018		Plate: photoconductor matrix 4 line to 10 line conversion	-hp-		
A35 †	**03460-66535**	**1**	**Assembly: Reversible Counting Decade**	**-hp-**		
A35A1	03460-69502		SAME AS A31A1, A32A1			
C1, C2	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C3, C4	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300V	
C5, C6	0140-0195		C: fx; mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C7, C8	0140-0193		C: fxd mica 82 pF 5%	04062	RDM15E820J3C	
C9, C10	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C11, C12	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300V	
C13, C14	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C15, C16	0140-0198		C: fxd mica 200 pF 5% 300 vdcw	04062	RDM15F201J3C	
C17	0140-0218		C: fxd mica 160 pF 2%	04062	RDM15F161G3C	
C18	0140-0195		C: fxd mica 130 pF 5% 300 vdcw	04062	RDM15F131J3C	
C19, C20	0140-0194		C: fxd mica 110 pF 5% 300 vdcw	04062	DM15F111J300V	
CR1, CR2	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR3 thru CR7	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR8, CR9	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR10 thru CR16	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR17, CR18	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR19 thru CR24	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR25, CR26	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR27 thru CR33	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR34 thru CR36	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR37	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR38	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR39	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR40	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd

† Std. Opt. 002, 004, or 006

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A35 (Cont'd)						
CR41	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR42	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR43, CR44	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR45	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
CR46	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR47, CR48	1901-0025		Diode: Si 100 mA at +1 100 piv 12 pF	93332	D3072	obd
CR49 thru CR52	1910-0016		Diode: Ge 60 wiv	03877	S3185G	
CR53, CR54	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
DS1A-H	2140-0044		Lamp: neon	-hp-		
DS2	1970-0009		Tube: special purpose 10 digit numeral indicator	83594	B5991	obd
Q1 thru Q25	1850-0062		TSTR: Ge PNP**	-hp-		
R1	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945	
R2, R3	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635	
R4	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R5, R6	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R7, R8	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525	
R9	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R10, R11	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935	
R12	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R13	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R14	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815	
R15	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R16	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925	
R17	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945	
R18, R19	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635	
R20	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R21, R22	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R23, R24	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525	
R25	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R26, R27	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935	
R28	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R29	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R30	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815	
R31	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R32	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925	
R33	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945	
R34, R35	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635	
R36	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R37, R38	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R39, R40	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525	
R41	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R42, R43	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935	
R44	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R45	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R46	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815	
R47	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R48	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925	
R49	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945	
R50, R51	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635	
R52	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R53	0683-2035		R: fxd comp 20 kilohms 5% 1/4 W	01121	CB2035	
R54	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R55, R56	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525	
R57	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A35 (Cont'd)						
R58, R59	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935	
R60	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R61	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R62	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815	
R63	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R64	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925	
R65, R66	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R67, R68	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925	
R69	0845-0001		Resistive network: 10-270 kilohms 2% 1/4 W	71590	obd	
R70	0686-4735		R: fxd comp 47 kilohms 5% 1/2 W	01121	EB4735	
R71	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R72, R73	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R74			Not assigned			
R75	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035	
R76	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R77	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	
R78	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R79, R80	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R81	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035	
R82	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R83	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	
R84	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R85, R86	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R87	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035	
R88	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R89	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	
R90	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R91, R92	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R93	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035	
R94	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R95	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	
R96	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R97	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R98	0686-6825		R: fxd comp 6800 ohms 5% 1/2 W	01121	EB6825	
R99	0758-0001		R: fxd prec met flm 3300 ohms 1% 1/2 W	19701	MF7C T-O	obd
R100	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R101, R102	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235	
R103	0683-3035		R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035	
R104	0683-1235		R: fxd comp 12 kilohms 5% 1/4 W	01121	CB1235	
R105	0683-3335		R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335	
R106	0757-0827		R: fxd prec met flm 2740 ohms 1% 1/2 W	19701	MF7C T-O	obd
R107, R108	0683-8225		R: fxd comp 8200 ohms 5% 1/4 W	01121	CB8225	
R109	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R110 thru R112	0683-8225		R: fxd comp 8200 ohms 5% 1/4 W	01121	CB8225	
R113	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R114	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R115	0683-3925		R: fxd comp 3900 ohms 5% 1/4 W	01121	CB3925	
R116, R117	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635	
R118, R119 †	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R120, R121	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525	
R122, R123	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935	
R124	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R125	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R126	0683-1815		R: fxd comp 180 ohms 5% 1/4 W	01121	CB1815	
R127	0683-3325		R: fxd comp 3300 ohms 5% 1/4 W	01121	CB3325	
R128, R129	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945	
R130, R131	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R132	0683-6835		R: fxd comp 68 kilohms 5% 1/4 W	01121	CB6835	
R133	0683-3935		R: fxd comp 39 kilohms 5% 1/4 W	01121	CB3935	
R134	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	

† A35R119 deleted after Serial No. 813-00451

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A35 (Cont'd)						
R135	0686-7525		R: fxd comp 7500 ohms 5% 1/2 W	01121	EB7525	
R136	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R137	0683-1535		R: fxd comp 15 kilohms 5% 1/4 W	01121	CB1535	
R138	0683-4715		R: fxd comp 470 ohms 5% 1/4 W	01121	CB4715	
R139	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R140	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
V1	1990-0018		Plate: photoconductor matrix 4 line to 10 line conversion	-hp-		
A36	**03460-67503**	**1**	**Assembly: Digital-to-Analog Resistor**	**-hp-**		
			NOTE Recalibrated assembly available on exchange basis, under -hp- Part No 03460-67505.			
R1 thru R14	0811-1103	14	R: set matched prec ww	-hp-		
R15	2100-1448		R: var ww 200 ohms 10% 1 W	09145	114106	obd
R16, R17			Not assigned			
R18, R19	0811-1104		R: set matched ww	-hp-		
R20			Not assigned			
R21	0757-0493		R: fxd prec met flm 15 ohms 1% 1/4 W	75042	CEB T-O	obd
R22	2100-1484		R: var ww lin 1000 ohms 5% 3/4 W	12697	76JA3 CM32589	
R23, R24	2100-1481		R: var ww lin 50 ohms 5% 3/4 W	12697	76JA3 CM32464	
R25	2100-1482		R: var ww lin 100 ohms 5% 3/4 W	12697	76JA3 CM32465	
R26	2100-1483		R: var ww lin 200 ohms 5% 3/4 W	12697	76JA3 CM32466	
R27, R28	2100-1478		R: var ww 50 ohms 10% 1 W	09145	114106	obd
R29	2100-0325		R: var ww 100 ohms 10% 1 W	09145	114106	obd
R30	2100-1448		R: var ww 200 ohms 10% 1 W	09145	114106	obd
A39 †	**03460-66539**	**1**	**Assembly: Converter Adapter**	**-hp-**		
C1	0160-0195	6	C: fxd cer die 0.001 microfarads 20% 250 vacw	56289	19C251A	
C2	0150-0014	1	C: fxd cer die 0.005 microfarads 500 vdcw	04222	D1-4	
C3, C4	0160-0195		C: fxd cer die 0.001 microfarads 20% 250 vacw	56289	19C251A	
C5, C6	0180-0100	2	C: fxd Ta elect 4.7 microfarads 10% 35 vdcw	56289	150D475X9035B2-DYS	
CR1 thru CR74	1901-0081		Diode: Si 50 wiv 10 ns 6 pF CR53 and CR65 Deleted at Serial No. 813-00451	82647	obd	
Q1 thru Q11	1853-0036	43	TSTR: Si PNP 2N3906	04713	2N3906-5	
Q12	1854-0022		TSTR: Si NPN**	-hp-		
Q13 thru Q17	1853-0036		TSTR: Si PNP 2N3906	04713	2N3906-5	
Q18	1854-0022		TSTR: Si NPN**	-hp-		
Q19	1853-0036		TSTR: Si PNP 2N3906	04713	2N3906-5	
Q20	1854-0022		TSTR: Si NPN**	-hp-		
Q21	1853-0036		TSTR: Si PNP 2N3906	04713	1N3906-5	

† Options 001, 003, 005, or 007

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A39 (Cont'd)					
Q22	0854-0022	1	TSTR: Si NPN**	-hp-	
Q23	1853-0036		TSTR: Si PNP 2N3906	04713	2N3906-5
R1 thru R5	0683-3635	93	R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R6 thru R8	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
			NOTE R6 and R112 are removed for 1224 code R7 and R11 are removed for 1248 code		
R9	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R10, R11	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R12 thru R16	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R17	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R18, R19	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R20	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R21 thru R25	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R26	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R27, R28	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R29	0683-1035		R: fxd comp 10 kilohms 5% 1/4W	01121	CB1035
R30 thru R33	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R34, R35	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R36 thru R38	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R39	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R40	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R41, R42	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R43 thru R46	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R47	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R48	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R49	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R50 thru R52	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R53	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R54	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R55, R56	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R57	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R58, R59	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R60	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R61	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R62 thru R64	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R65	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R66	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R67 thru R72	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735
R73	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R74, R75	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R76 thru R79	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R80, R81	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R82 thru R85	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R86	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R87	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R88	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R89	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R90	0683-5125	2	R: fxd comp 5100 ohms 5% 1/4 W	01121	CB5125
R91, R92	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R93	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R94	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R95	0683-5125		R: fxd comp 5100 ohms 5% 1/4 W	01121	CB5125
R96	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A39 (Cont'd)						
R97	0698-4510	1	R: fxd prec met flm 84.5 kilohms 1% 1/8 W	91637	MFF-1/8 T-1	
R98	0757-0272	1	R: fxd prec met flm 52.3 kilohms 1% 1/8 W	75042	CEAT-O	
R99	0698-3452	1	R: fxd prec met flm 147 kilohms 1% 1/8 W	91637	MFF-1/8 T-1	
R100	0698-3345	1	R: fxd comp 330 kilohms 5% 1/4 W	01121	CB3345	
R101	0683-1055	2	R: fxd comp 1 megohm 5% 1/4 W	01121	CB1055	
R102	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R103	0683-2705	1	R: fxd comp 27 ohms 5% 1/4 W	01121	CB2705	
R104, R105	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R106	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R107	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R108, R109	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R110	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R111	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R112	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W R112 was first installed in instrument No.813-00451	01121	CB1045	
A40	**03460-66540**	**1**	**Assembly: Decimal Lights**	**-hp-**		
CR1 thru CR5	1901-0025		Diode: Si 100 mA at + 1 V 100 piv 12 pF	93332	D3072	obd
DS1			Not assigned			
DS2 thru DS6	2140-0028	5	Lamp: glow 1/15 W breakdown voltage 65 vac neon	24455	NE-2E Frosted	
R1	0683-6835		R: fxd comp 68 kilohms 5% 1/4 W	01121	CB6835	
R2	0683-8235		R: fxd comp 82 kilohms 5% 1/4 W	01121	CB8235	
R3	0683-1545	1	R: fxd comp 150 kilohms 5% 1/4 W	01121	CB1545	
R4	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R5 thru R8	0683-1055		R: fxd comp 1 megohm 5% 1/4 W	01121	CB1055	
A41	**03460-66541**	**1**	**Assembly: Automatic Range Selector**	**-hp-**		
A41A1	03460-69505		Assembly: Nixie Decoding includes DS1A-H, R12 and:	-hp-		
	0845-0001	1	Resistive network	71590	obd	
	0905-0043	1	Gasket: rubber	-hp-		
	0905-0051	1	Gasket: felt	-hp-		
	1990-0201	1	Plate: photoconductor	-hp-		
	2140-0044	1	Lamp: neon	-hp-		
	5040-4569	1	Socket: nixie	-hp-		
	5212A-83C	1	Cover: column	-hp-		
	03440-63001	1	Block: photoconductor	-hp-		
	05212-0011	1	Shield: photo plate	-hp-		
C1 thru C4	0160-0195		C: fxd cer die 1000 pF 20% 250 vacw	56289	19C251A	
C5	0170-0079	1	C: fxd my die 0.047 microfarad 20% 50 vdcw	84411	601PE	
CR1 thru CR71	1901-0081		Diode: Si 50 wiv 10 ns 6 pF	82647	obd	
CR72, CR73			Not assigned			
CR74 thru CR79	1901-0081		Diode: Si 50 wiv 10 ns 6 pF	82647	obd	
DS1A-H	2140-0044		Lamp: glow neon breakdown voltage 64-80 vdc	-hp-		
DS2	1970-0012†	1	Tube: Function display	83594	B5992	obd
	1970-0015††	1		83594	B59936	obd
			NOTE DS2 is not included in part number 03460-66541. Order DS2 separately according to part number listed.			
DS3	1970-0009		Tube: special purpose digit numeral indicator	83594	B5991	obd

† Standard and Option 001, 004, or 005
†† Options 002, 003, 006, or 007

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A41 (Cont'd)						
K1	0490-0399	1	Relay: electromagnetic coil w/reed switch	-hp-		
Q1, Q2	1853-0036		TSTR: Si PNP 2N3906	04713	2N3906-5	
Q3	1854-0022		TSTR: Si NPN**	-hp-		
Q4	1853-0036		TSTR: Si PNP 2N3906	04713	2N3906-5	
Q5	1854-0022		TSTR: Si NPN**	-hp-		
Q6 thru Q11	1853-0036		TSTR: Si PNP 2N3906	04713	2N3906-5	
Q12	1854-0022		TSTR: Si NPN**	-hp-		
Q13 thru Q15	1853-0036		TSTR: Si PNP 2N3906	04713	2N3906-5	
Q16	1854-0071	1	TSTR: Si NPN 2N3391	04713	MPS3391-5	
Q17 thru Q27	1853-0036		TSTR: Si PNP 2N3906	04713	2N3906-6	
R1	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R2	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R3	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R4	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945	
R5 thru R10	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635	
R11	0683-3945		R: fxd comp 390 kilohms 5% 1/4 W	01121	CB3945	
R12	0845-0001		Resistive network: 10 270 kilohms 2% 1/4 W	71590	obd	
R13	0683-3945		R: fxd comp 390 kilohms 1/4 W	01121	CB3945	
R14	0683-3915	1	R: fxd comp 390 ohms 5% 1/4 W	01121	CB3915	
R15	0683-2745	1	R: fxd comp 270 kilohms 5% 1/4 W	01121	CB2745	
R16	0757-0852	1	R: fxd prec met flm 47.5 kilohms 5% 1/2 W	75042	CEC T-O	obd
R17	0757-0856	1	R: fxd prec met flm 75.0 kilohms 1% 1/2 W	000LM	obd	
R18	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R19	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R20	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R21	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R22	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R23	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R24	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R25	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R26	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R27	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R28	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R29	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R30	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R31	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R32, R33	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R34	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R35, R36	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R37, R38	0683-2745		R: fxd comp 270 kilohms 5% 1/4 W	01121	CB2745	
R39, R40	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635	
R41	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R42	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R43	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R44, R45	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R46	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R47	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R48	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R49 thru R50	0683-5635		R: fxd comp 56 kilohms 5% 1/4 W	01121	CB5635	
R51, R52	0683-2745		R: fxd comp 270 kilohms 5% 1/4 W	01121	CB2745	
R53	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R54	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R55	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R56, R57	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R58	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R59	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R60	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A41 (Cont'd)					
R61	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R62	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R63	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R64	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R65	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R66 thru R68	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R69	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R70	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R71	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R72	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R73	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R74, R75	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R76	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R77	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R78	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R79	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R80	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R81	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R82	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R83	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R84	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R85	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R86	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R87	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R88, R89	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R90	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R91	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01191	CB1835
R92	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R93	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R94	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R95	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R96, R97	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R98	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R99	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R100	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R101	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R102			Not assigned		
R103	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R104	0686-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R105	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R106	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R107	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R108	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R109	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R110	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035
R111	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R112	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
V1	1990-0201	1	Plate: photoconductor matrix	-hp-	
A42	**03460-66542**	**1**	**Assembly: Sample Delay, DC Enable (Options 004, 005)**	**-hp-**	
C1	0160-0195		C: fxd cer 1000 pF 20% 250 vacw	56289	19C251A
C2	0180-0100		C: fxd Ta elect 4.7 microfarads 10% 35 vdcw	56289	150D475X9035B2-DYS

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A42 (Cont'd)						
CR1 thru CR10	1901-0081		Diode: Si 50 piv 6 pF 10 ns			
Q1 thru Q4	1853-0036	4	TSTR: Si PNP 2N3906	04713	SPS-3612	
Q5	1854-0022		TSTR			
R1 thru R9	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R10	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
R11	0683-8225		R: fxd comp 8200 ohms 5% 1/4 W	01121	CB8225	
R12	0683-1835		R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835	
R13	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R14 thru R17	0683-3635	8	R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R18	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R19	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R20	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R21	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R22	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R23, R24	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635	
R25 thru R27	0683-1035		R: fxd comp 10 kilohms 5% 1/4 W	01121	CB1035	
R28	0683-2705	1	R: fxd comp 27 ohms 5% 1/4 W	01121	CB2705	
R29	0683-3635		R: fxd comp 36 kilohms 5% 1/4 Q	01121	CB3635	
R30	0683-3345	1	R: fxd comp 330 kilohms 5% 1/4 W	01121	CB3345	
R31	0683-1055	1	R: fxd comp 1 megohm 5% 1/4 W	01121	CB1055	
R32	0757-0465	1	R: fxd met flm 100 kilohms 1% 1/8 W			
TP1, TP2	0360-1514	2	Terminal	-hp-		
A43 †	**03460-63402**	**1**	**Assembly: Input Range and Sensitivity Selector**	**-hp-**		
CR1 thru CR10	1901-0025		Diode: Si 100 mA at +1 V 100 piv 12 pF	93332	D3072	obd
E1	03460-05501	2	Can: Isothermal	-hp-		
K1 thru K3	0490-0817	13	Relay: reed SPST normally open	-hp-		
K4, K5	0490-0818	6	Relay: dry reed switch	-hp-		
K6 thru K8	0490-0817		Relay: reed SPST normally open	-hp-		
K9	0490-0818		Relay: dry reed switch	-hp-		
K10	0490-0049		Relay: reed SPST normally open	-hp-		
L1 thru L10	9100-0352	10	Coil: electromagnetic	71707	obd	
R1	0698-4941	1	R: fxd met flm 66.5 kilohms 1% 1/2 W			
R2	0757-0310	1	R: fxd prec met flm 133 kilohms 1% 1/2 W	19701	MF7C T-O	obd
R3, R4	0811-1101	6	R: set matched input attenuator (includes R3, R4, R7, R16)	-hp-		
R5	0757-0740		R: fxd prec met flm 2.21 kilohms 1% 1/4 W	19701	MF6C T-O	obd
R6	2100-1485		R: var ww lin 20 kilohms 5% 3/4 W	12697	76JA3 CM32591	
R7	0811-1101		R: set matched input attenuator	-hp-		
R8	0757-0718	1	R: fxd prec met flm 200 ohms 1/4 W	19701	MF6C T-O	obd

† (Std and Opt 001, 002, and 003)

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A43 (Cont'd)					
R9	2100-1485		R: var ww lin 20 kilohms 5% 3/4 W	12697	76JA3 CM32591
R10	0811-1101		R: set matched input attenuator	-hp-	
R11	0811-1357	1	R: fxd prec ww 9000 ohms 0.01% 1/8 W	-hp-	
R12	0811-1362	1	R: fxd prec ww 1000 ohms 0.01% 1/4 W	-hp-	
R13 thru R17	0683-4315		R: fxd comp 430 ohms 5% 1/4 W	01121	CB4315
R18	0811-1342	1	R: fxd prec ww 200 ohms 0.01% 1/4 W	-hp-	
R19	0811-1341	1	R: fxd prec ww 133.333 ohms 0.01% 1/4 W	-hp-	
R20	0811-1343	1	R: fxd prec ww 1666.67 ohms 0.01% 1/4 W	-hp-	
R21 thru R25	0683-4315		R: fxd comp 430 ohms 5% 1/4 W	01121	CB4315
A44	**03460-66544**	**1**	**Assembly: DC Enable**	**-hp-**	
R1 thru R9	0686-1045	9	R: fxd comp 100 kilohms 5% 1/2 W	01121	EB1045
R10	0686-8225	1	R: fxd comp 8200 ohms 5% 1/2 W	01121	EB8225
R11	0686-2735	1	R: fxd comp 27 kilohms 5% 1/2 W	01121	EB2735
			NOTE R6 is removed for 1 2 2 4 code R7 is removed for 1 2 4 8 code		
A45	**03460-66545**	**1**	**Assembly: Printer Bias**	**-hp-**	
R1 thru R5	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R6	0683-8225		R: fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R7	0683-2735		R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735
A47	**03460-66547**	**1**	**Assembly: Filter Enable (Options 004, 005, 006, 007)**	**-hp-**	
CR1 thru CR7	1901-0025	7	Diode: Si 100 piv 12 pF 100 mA	93332	D3072
Q1 thru Q3	1853-0036	3	TSTR: Si PNP 2N3906	04713	SPS-3612
Q4	1854-0215	1	TSTR: Si NPN 2N3904	04713	SPS-3611
R1	0683-3635	2	R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R2, R3	0683-8225		R: fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R4	0683-3635		R: fxd comp 36 kilohms 5% 1/4 W	01121	CB3635
R5, R6	0683-8225		R: fxd comp 8200 ohms 5% 1/4 W	01121	CB8225
R7	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045
R8	0683-2235		R: fxd comp 22 kilohms 5% 1/4 W	01121	CB2235
R9	0683-3335	1	R: fxd comp 33 kilohms 5% 1/4 W	01121	CB3335
R10	0683-1835	1	R: fxd comp 18 kilohms 5% 1/4 W	01121	CB1835
R11	0683-3035	1	R: fxd comp 30 kilohms 5% 1/4 W	01121	CB3035
R12	0683-5125	1	R: fxd comp 5100 ohms 5% 1/4 W	01121	CB5125
R13 thru R17	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A47 (Cont'd)						
R18	0683-8225		R: fxd comp 8200 ohms 5% 1/4 W	01121	CB8225	
R19	0683-2735	1	R: fxd comp 27 kilohms 5% 1/4 W	01121	CB2735	
A50	**03460-63403**	**1**	**Assembly: Input Range and Sensitivity Selector (Options 004, 005, 006, 007)**	**-hp-**		
C1	0160-3236	1	C: fxd teflon 0.33 microfarads 10% 50 vdcw	01884	AH8A1A334K	
C2	0160-3235	1	C: fxd teflon 0.056 microfarads 10% 50 vdcw	01884	AH8A1A563K	
CR1 thru CR12	1901-0025		Diode: Si 100 piv 12 pF 100 mA	93332	D3072	obd
E1	03460-05501	2	Can: Isothermal	-hp-		
K1 thru K3	0490-0817		Relay: reed SPST normally open	17675	DRVT-1	
K4, K5	0490-0818		Relay: reed	95348	MR-906	
K6	0490-0756	1	Relay: reed	-hp-		
K7, K8	0490-0817		Relay: reed SPST normally open	17675	DRVT-1	
K9	0490-0818		Relay: reed	95348	MR-906	
K10	0490-0817		Relay: reed SPST normally open	17675	DRVT-1	
K11, K12	03460-61902	2	Relay: reed SPDT	-hp-		
L1 thru L10	9100-0352	10	Coil: reed relay	-hp-		
L11, L12	0490-0757	2	Coil: reed relay	-hp-		
R1, R2	0757-0856	2	R: fxd met flm 75 kilohms 1% 1/2 W	75042	CEC T-O	obd
R3, R4	0811-1101		R: set matched input attenuator	-hp-		
R5	0757-0740	1	R: fxd prec met flm 2210 ohms 1% 1/4 W	91637	MFF 1/4 T-1	obd
R6	2100-1485		R: var ww lin 20 kilohms 5% 3/4 W	12697	76JA3CM32591	
R7	0811-1101		R: set matched input attenuator	-hp-		
R8	0757-0718	1	R: fxd prec met flm 200 ohms 1% 1/4 W	19701	MF6C T-O	obd
R9	2100-1485		R: var ww lin 20 kilohms 5% 3/4 W	12697	76JA3CM32591	
R10	0811-1101		R: set matched input attenuator	-hp-		
R11	0811-1357	1	R: fxd prec ww 9000 ohms 0.01% 1/8 W	-hp-		
R12	0811-1362	1	R: fxd prec ww 1000 ohms 0.01% 1/4 W	-hp-		
R13 thru R17	0683-4315	9	R: fxd comp 430 ohms 5% 1/4 W	01121	CB4315	
R18	0811-1342	1	R: fxd prec ww 200 ohms 0.01% 1/4 W	-hp-		
R19	0811-1341	1	R: fxd prec ww 133.333 ohms 0.01% 1/4 W	-hp-		
R20	0811-1343	1	R: fxd prec ww 1666.67 ohms 0.01% 1/4 W	-hp-		
R21			Not assigned			
R22 thru R25	0683-4315		R: fxd comp 430 ohms 5% 1/4 W	01121	CB4315	
R26	0757-0853	1	R: fxd met flm 51.1 kilohms 1% 1/2 W	91637	MFF 1/2 T-1	
R27	0757-0352	1	R: fxd met flm 150 kilohms 1% 1/2 W	75042	CEC T-O	obd
R28	0757-0839	1	R: fxd met flm 10 kilohms 1% 1/2 W	19701	MF7C T-O	
R29, R30	0686-1025	1	R: fxd comp 1000 ohms 5% 1/2 W	01121	EB1025	

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
Chassis						
B1	3140-0030		Motor: fan	73793	35060-6	
C1	0180-0384		C: fxd Al elect 1500 microfarads +100% -10% 40 vdcw	56289	D39590 6439	
C2	0180-0383	1	C: fxd Al elect 600 microfarads +75% -10% 75 vdcw	56289	D39591 6439	
C3	0150-0093	1	C: fxd cer 0.01 microfarads +80% -20% 100 vdcw	91418	TA	
DS1	1450-0049	1	Light: (TRIGGERING) indicator NE-2E neon in clear plastic housing	08717	858-C/NE2E	
DS2	1450-0115	1	Light: (OVERLOAD) indicator lamp type 1730 in plastic housing	08717	858-C-1730	
F1	2110-0007	1	Fuse: cartridge 1 amp slow-blow (115 V operation)	75915	313001	
J1 thru J7	1251-0135	13	Connector: pc 15 tuning fork type contacts	000XX	SD615UR	
J8, J9	1251-0172	3	Connector: pc 22 ribbon type contacts	76530	250-22-30-210	
J10, J11	1251-0135		Connector: pc 15 tuning fork type contacts	000XX	SD615UR	
J12	1251-0172		Connector: pc 22 ribbon type contacts	76530	250-22-30-210	
J13	1251-0135		Connector: pc 15 tuning fork type contacts	000XX	SD615UR	
J14 thru J18	1251-1263	7	Connector: pc 30 ribbon type contacts	07233	251-15-30-261	
J19	1251-0208	1	Connector: pc 22 tuning fork type contacts	000XX	SD622UR	
J20 thru J22	1251-0135		Connector: pc 15 tuning fork type contacts	000XX	SD615UR	
J23, J24	1251-1263		Connector: pc 30 ribbon type contacts	07233	251-15-30-261	
J25	1200-0056	1	Socket: tube 9 pin miniature	91662	512-S-BC	obd
J26	1251-0349	1	Connector: male 3 pin shielded input	04919	7282	obd
J27	1251-0085	1	Connector: female 36 pin miniature with clamp	71785	57-40360 (white numbers)	
J28	1251-0087	1	Connector: female 50 pin miniature with clamp	71785	57-40500 (white numbers)	
J29	1251-0148	1	Connector: ac power cord receptacle	87930	H-1061-2	
J30, J31	1510-0032	1	Binding post: red w/o solder turret brass	-hp-		
J32	5060-4971	1	Assembly: connector	-hp-		
Q1 thru Q4	1850-0098	4	TSTR: Ge PNP**	-hp-		
R1	2100-0171	2	R: var comp lin 2/switch 200 kilohms 20% 1/4 W (TRIGGERING RATE)	71450	Type VF-45	
R2	0683-4735		R: fxd comp 47 kilohms 5% 1/4 W	01121	CB4735	
R3	0683-1045		R: fxd comp 100 kilohms 5% 1/4 W	01121	CB1045	
R4, R5	0683-0125		R: fxd comp 1 kilohm 5% 1/4 W	01121	CB1025	
S1	3100-1702	1	Switch: (LOCAL-REMOTE TRIGGERING) rotary 3-pos	76854	Type K	obd
S2	3101-0014	1	Switch: pushbutton (TRIGGERING) SPD2	82389	45-1106	obd
S3	2100-0171		R: var comp lin w/switch 200 kilohms 20% 1/4 W (TRIGGERING RATE)	71450	Type VF-45	
S4	3100-1703	1	Switch: (REAR-FRONT) rotary 2-pos	76854	Type F	obd
S5	3101-0802	1	Switch: (RANGE) pushbutton 6-button	76854	Type 130	obd
S6	3101-0033	1	Switch: slide (line voltage) DPDT	42190	4633	obd
S7	3101-0095	1	Switch: slide (+V/F CHECK-) DP3T	79727	G-728-1 flush button w/SD slotted	

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.	
Chassis (Cont'd)						
T1	9100-0330	1	Transformer: power	-hp-		
T2, T3	9100-0331	2	Transformer: pulse	-hp-		
W1	8120-0078	1	Assembly: cable power smooth black extra limp 7.5 feet long	70903	KH-4147	obd
			MISCELLANEOUS			
	5212A-83C	1	Assembly: cover lamp	-hp-		
	03460-01214	1	Bar: rubber bumper	-hp-		
	5212A-83H	1	Block: photoconductor	-hp-		
	03460-01201	1	Bracket: fan	-hp-		
	1410-0094	1	Bushing: input binding post	95264	obd	
	03460-05501	1	Can: isothermal	-hp-		
	9211-1246	1	Carton, Inner: shipping	-hp-		
	9211-0829	1	Carton, Outer: shipping	-hp-		
	1400-0040	1	Clip: capacitor steel black oxidized finish (used on A17 assembly)	80033	E-50008-007	
	0340-0035	1	Contact pin on top guard cover	98291	X-L-041762-8	
	03460-04108	1	Cover: oven assembly	-hp-		
	9220-1206	1	Filler: shipping	-hp-		
	0905-0051	1	Gasket: felt black adhesive backed	78471	obd	
	0905-0043	1	Gasket: photoconductor black silicone rubber	-hp-		
	03460-24702	1	Guard: terminal	-hp-		
	03460-01204	1	Gusset: guard	-hp-		
	03460-66501	1	Housing: oven	-hp-		
	03460-04102	1	Holddown, Board	-hp-		
	0360-1118	1	Insulator: feed-thru teflon (cloverleaf terminal) (used on A5, A6, A8, and A36 assemblies)	98291	FT-E-10	
	0340-0008	1	Insulator: standoff teflon (long turret terminal) (used on A6 assembly)	98291	ST-1000-L2	
	0340-0127	1	Insulator: standoff teflon (short turret terminal) (used on A6 and A21 assemblies)	98291	ST-250	obd
	0340-0128	1	Insulator: standoff teflon ("Y" terminal) (used on A6, A17, and A21 assemblies)	98291	ST-1500SL	obd
	2140-0044	1	Lamp: glow neon breakdown voltage 64-80 vdc (part of readout block assemblies)	-hp-		
	03460-90004	1	Manual: Operating and Service	-hp-		
	05212-0011	1	Shield: photoplate	-hp-		
	5040-0641	1	Socket: 10 digit numeral indicator tube	-hp-		
	1460-0218	1	Spring: tubular phosphor bronze nickel plated (used on A21 assembly)	91260	obd	
	0340-0039	1	Standoff: bushing on top guard cover	00866	HP-3000T-1	
	03460-01206	1	Support: guard	-hp-		
	0440-0006		Thermostat: oven Hg			

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
			ACCESSORY KIT (MP 13)		
	5060-0049	1	Assembly: board extender	-hp-	
	5060-0630	1	Assembly: board extender	-hp-	
	5020-0708	1	Bracket: left hand rack mount for 5 inch instrument	-hp-	
	5020-0709	1	Bracket: right hand rack mount for 5 inch instrument	-hp-	
	5040-0164	1	Filler strip: large gray	-hp-	
	5950-4401	1	Instructions: rack mount conversion	-hp-	
	2550-0018	1	Screw: machine 8-32 x 7/16" Phillips drive	-hp-	
	11065A	1	Rear Input Cable	-hp-	
	11085A	1	Remote Control Cable	-hp-	

Table 7-1. Model 3460B Schematic Directory

ASSY NO.	FUNCTION	PAGE	CONNECTOR(S)	OPTIONS							
				STD	001	002	003	004	005	006	007
A1	Integrator	7-5	J1	S	1	2	3	4	5	6	7
A2	Precision Current Pulse Generator	7-5	J2	S	1	2	3	4	5	6	7
A3	Inguard Power Supply (I 17.5 V)	7-5	J3	S	1	2	3	4	5	6	7
A4	Inguard Power Supply (I 25 V)	7-7	J4	S	1	2	3	4	5	6	7
A5	Voltage-to-Current Converter	7-7	J5	S	1	2	3	4	5	6	7
A8	Digital-to-Analog Resistor Assembly	7-23	J19		1		3		5		7
A9	N_6 Reversible Counting Decade	7-9	J6		1		3		5		7
A10	N_5 Reversible Counting Decade	7-9	J7		1		3		5		7
A11	N_4 Reversible Counting Decade /D-to-A Coil Drive	7-11	J8		1		3		5		7
A12	N_3 Reversible Counting Decade /D-to-A Coil Drive	7-11	J9		1		3		5		7
A13	N_2 and N_1 Reversible Counting Decade/D-to-A Coil Drive	7-13	J10 and J11		1		3		5		7
A14	Timing and Control	7-15	J12 and J13	S	1	2	3	4	5	6	7
A16	Counter Driver	7-17	J20 and J21	S	1	2	3	4	5	6	7
A17	Sample Period Generator	7-19	J22	S	1	2	3	4	5	6	7
A18	Out-Guard Power Supply	7-21	J23	S	1	2	3	4	5	6	7
A19	Reference Power Supply	7-23	—	S	1	2	3	4	5	6	7
A20	Trigger Input	7-15	—	S	1	2	3	4	5	6	7
A21	Digital-to-Analog Relays	7-23	—	S	1	2	3	4	5	6	7
A31	N_6 Reversible Counting Decade	7-25	J6	S		2		4		6	
A32	N_5 Reversible Counting Decade	7-25	J7	S		2		4		6	
A33	N_4 Reversible Counting Decade /D-to-A Coil Drive	7-27	J8	S		2		4		6	
A34	N_3 Reversible Counting Decade /D-to-A Coil Drive	7-27	J9	S		2		4		6	
A35	N_2 and N_1 Reversible Counting Decade/D-to-A Coil Drive	7-29	J10 and J11	S		2		4		6	
A36	Digital-to-Analog Resistor Assembly	7-23	J19	S		2		4		6	
A39	Converter Adapter	7-31	J16 and J17			2	3			6	7
A40	Decimal Lights	7-33	—	S	1	2	3	4	5	6	7
A41	Range and Sensitivity Selector	7-33	J14 and J15	S	1	2	3	4	5	6	7
A42	Sample Delay, DC Enable	7-35	J16 and J17					4	5		
A43	Range and Sensitivity Resistors	7-7	—	S	1	2	3				
A44	DC Enable	7-33	J17	S	1						
A45	Printer Bias	7-37	J33	S	1	2	3				
A47	Filter Enable Printer Bias	7-37	J33					4	5	6	7
A50	Range, Sensitivity and Filter	7-7	—					4	5	6	7

SECTION VII
CIRCUIT DIAGRAMS

7-1. INTRODUCTION.

7-2. This section contains the circuit diagrams necessary for the operation and maintenance of the Model 3460B Digital Voltmeter. Included are block diagrams, schematics, component location diagrams, and an assembly location diagram. Table 7-1 identifies the assembly reference designators.

7-3. BLOCK DIAGRAM.

7-4. The block diagram shows the relationship between the assemblies of the instrument. Signal flow between assemblies and significant portions of assemblies as well as major feedback paths are shown. The block diagram is used to develop an understanding of the basic theory of operation.

7-5. SCHEMATIC DIAGRAMS.

7-6. The circuitry contained within each assembly is shown in the schematic diagrams. These diagrams are used to develop an understanding of the detailed theory of operation of each assembly and as an aid in isolating troubles within an assembly.

7-7. ASSEMBLY LOCATION DIAGRAM.

7-8. The Assembly Location Diagram shows the physical location of each assembly along with all option assemblies within the instrument. The Assembly Location Diagram is used to locate assemblies, jacks, and components not mounted on a printed circuit board.

7-9. COMPONENT LOCATION DIAGRAMS.

7-10. The component location diagrams show the physical location of parts mounted on an assembly. Each part is identified by a reference designator.

GENERAL NOTES

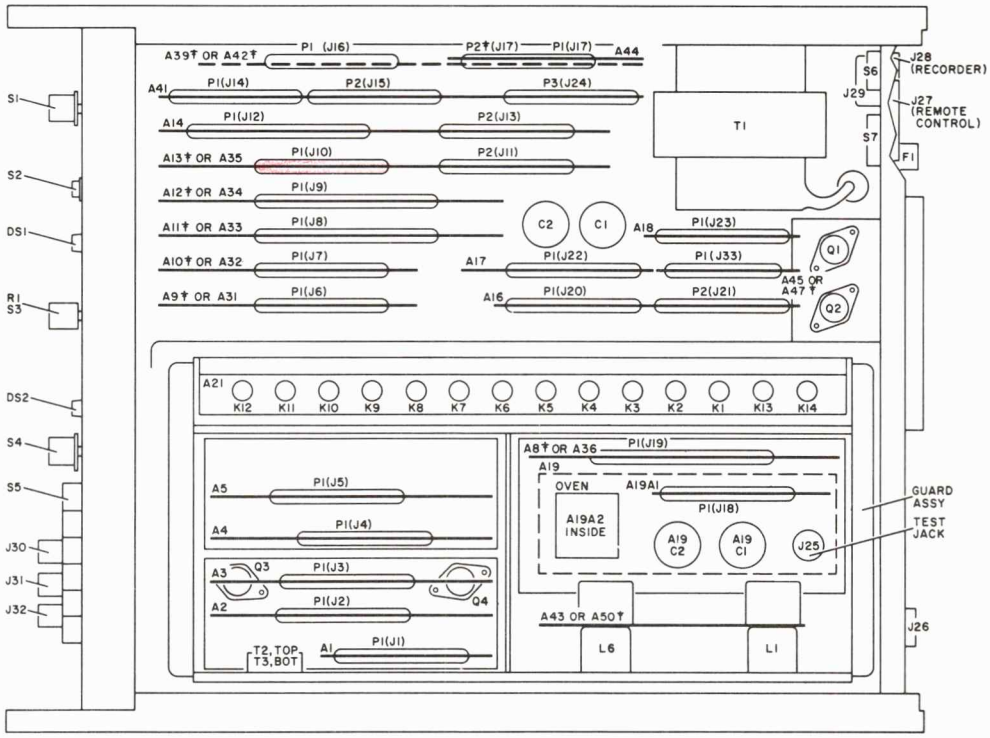
N_1, N_2, N_3, N_4, N_5 and N_6 denote 1st, 2nd, 3rd, 4th, 5th and 6th digits respectively.

"RCD" denotes Reversible Counting Decade.

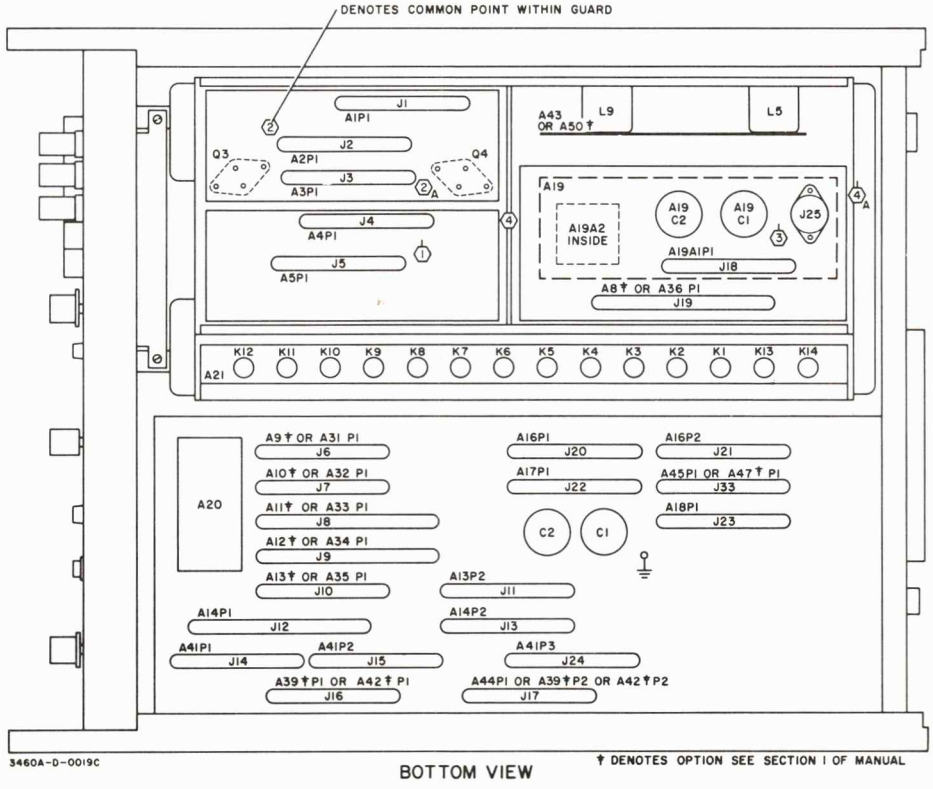
"D-to-A" denotes Digital-to-Analog.

"V-to-F" denotes Voltage-to-Frequency.

See Figure 5-7 for location of adjustments and test points.



TOP VIEW



BOTTOM VIEW

Figure 7-1. Assembly Location

NOTES

1. ⏚ POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).

   ▽ A4, A5 DECK; ±25 VOLT POWER SUPPLY COMMON.

   ▽ A1, A2, A3 DECK; ±17.5 VOLT POWER SUPPLY COMMON.

   ▽ A19, A36 OR A8 DECK; REFERENCE POWER SUPPLY COMMON.

   ▽ GUARD.

2. ——— DENOTES MAIN SIGNAL PATH.

   – – – – – DENOTES FEEDBACK PATH.

3. ▭ DENOTES FRONT PANEL MARKING.

   ◯ DENOTES FRONT PANEL CONTROL.

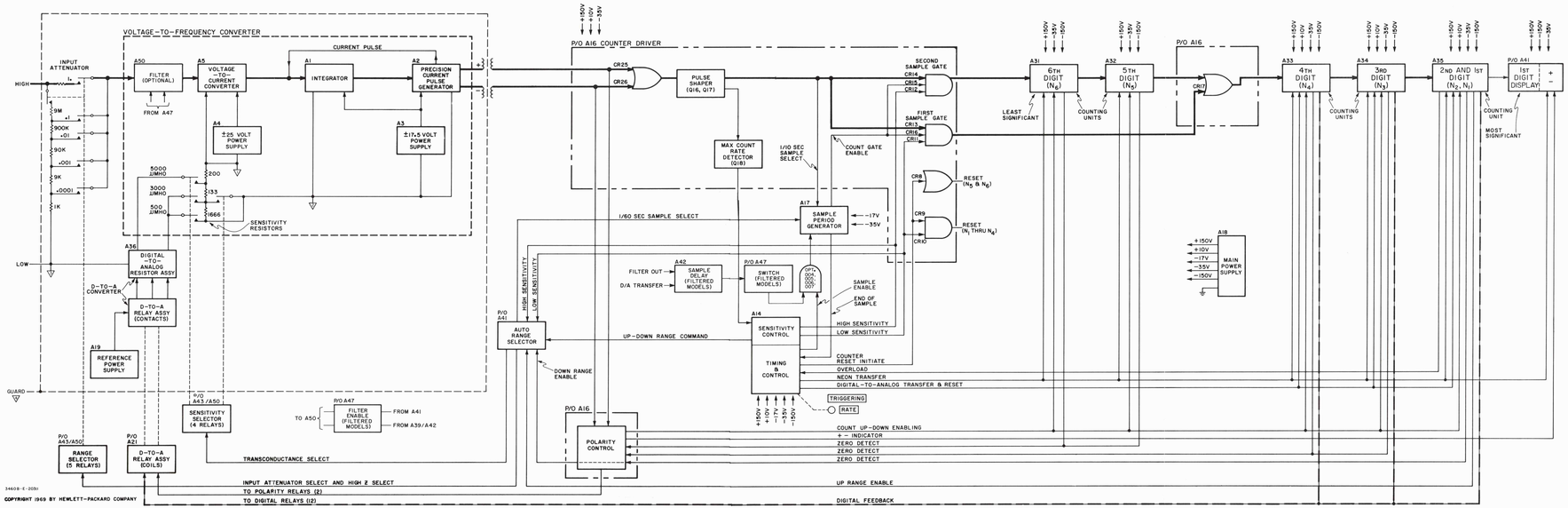
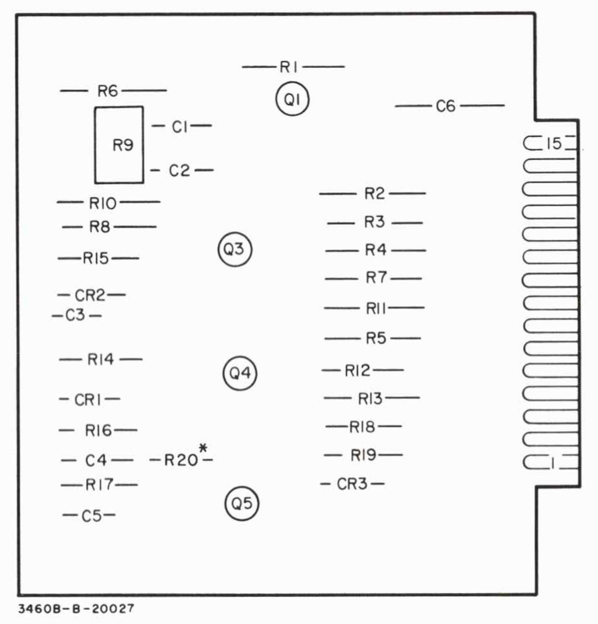
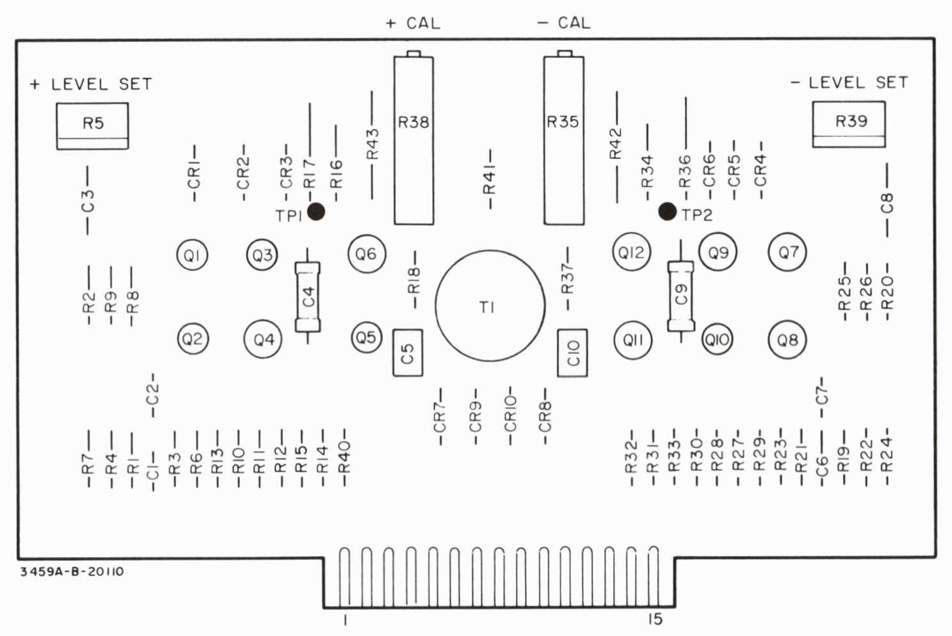


Figure 7-2. Detailed Block Diagram

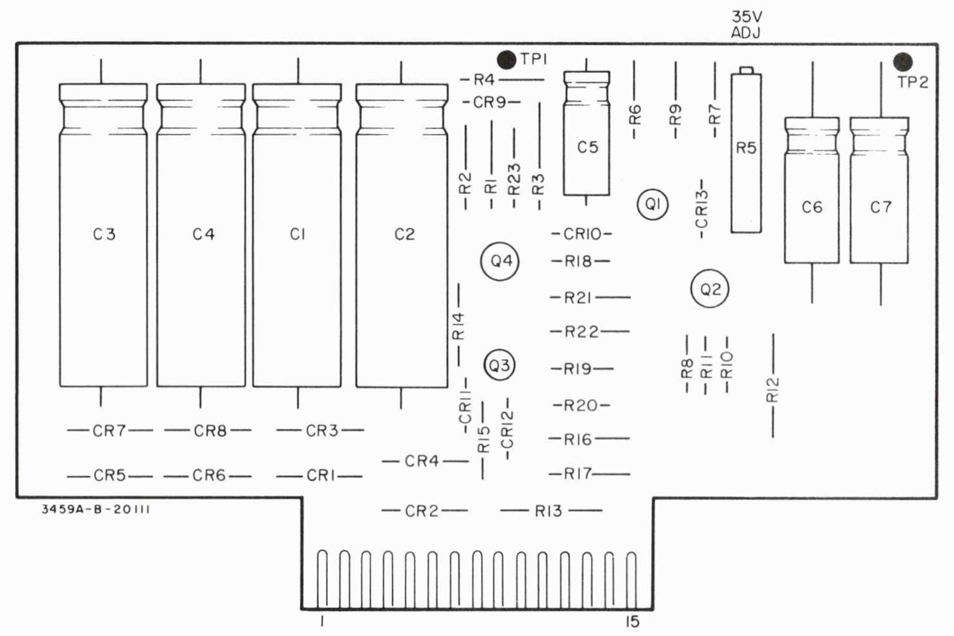


A1

*R20 ADDED AT SERIAL NO. 709-00176



A2



A3

Figure 7-3. Component Location Diagrams; Assemblies A1, A2 and A3

NOTES

1. VALUES IN OHMS AND MICROFARADS UNLESS OTHERWISE NOTED.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED ON A1, A2, A3; PREFIX WITH A1, A2, A3 AS APPLICABLE.
3. ⏚ POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).
   ▽ A1, A2, A3 DECK; ±17.5 VOLT POWER SUPPLY COMMON.
   ▽ GUARD.
4. ——— DENOTES ETCHED CIRCUIT BOARD.
   ——— DENOTES MAIN SIGNAL PATH.
   — — — DENOTES FEEDBACK PATH.
   ⊘ DENOTES SCREWDRIVER ADJUST.
   018 DENOTES WIRE COLOR USING STANDARD COLOR CODE. (e.g. 918 = WHITE, BROWN, GRAY)

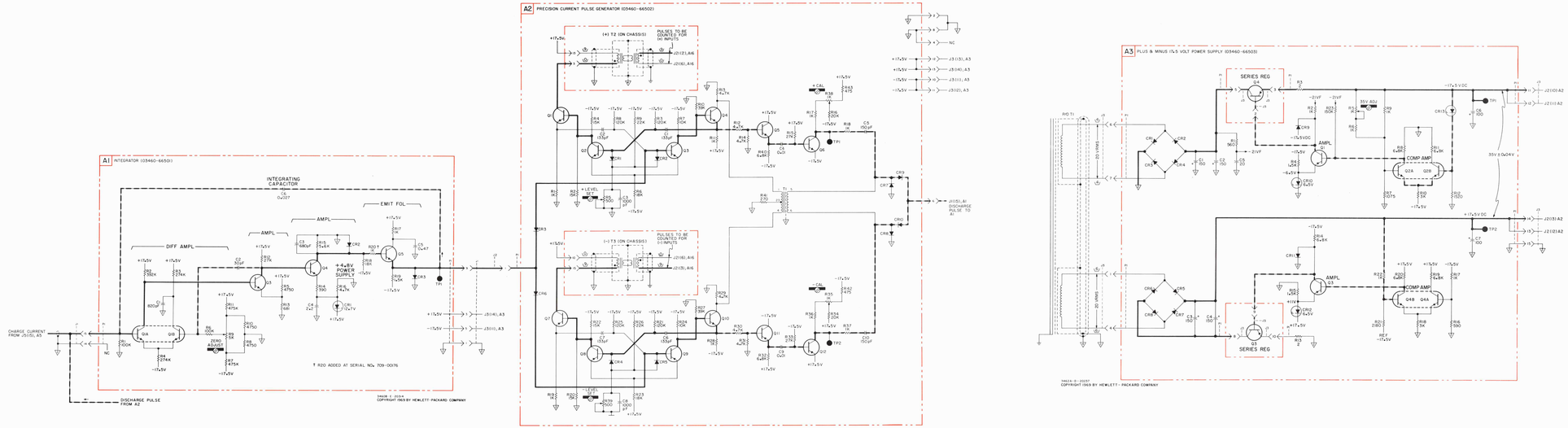
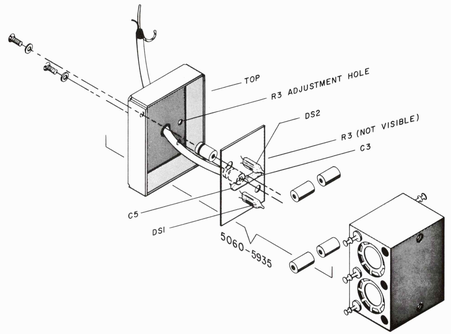


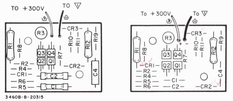
Figure 7-4. Current-to-Frequency Converter; Assemblies A1, A2 and A3

DESIG.	hp- PART NO.	QTY	DESCRIPTION
C1, C2 C3, C5 C4	0160-3517 0160-3435 0180-0309	2 2 1	C: fxd 0.018 microfarad 10% 50 vdcw C: fxd 0.047 microfarad 10% 50 vdcw C: fxd 4.7 microfarads 20% 10 vdcw (Replaces 10 microfarad capacitors on some boards)
CR1, CR2 CR3	1902-0031 1902-0666	2 1	Diode: 13 V 400 mW Diode: 162 V 5% 1 W
DS1, DS2	2140-0234	2	Lamp, Neon: NE2U
Q1, Q4	1854-0358	4	TSTR: NPN
R1 R2, R4 R5*, R6* R7 R8, R9 R10, R11 R12	0761-0092 0683-3935 0684-1231 0684-1051 0683-2255 0761-0083	1 2 2 1 2 2 1	R: fxd 180 kilohms 5% 1 W R: fxd 39 kilohms 5% 1/4 W R: fxd 301-453K 1/8 W See Note R: fxd 12 kilohms 10% 1/4 W R: fxd 1 megohm 10% 1/4 W R: fxd 2.2 megohms 5% 1/4 W R: fxd 68 kilohms 5% 1 W
5060-5935 Neon Oscillator Modification Kit consits of:			
	5060-5916 5000-7172 0380-0877 2190-0879 2190-0004 2200-0091 P-5060-5935	1 1 6 2 2 2 1	Circuit Board Assembly Cover, Chopper Spacer, Fiber Washer, Nylon Washer, Lock Screw Service Note

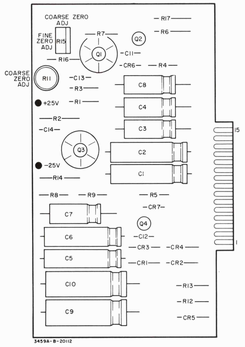
* Selected for symmetrical 210 Hz output with R3 centered.



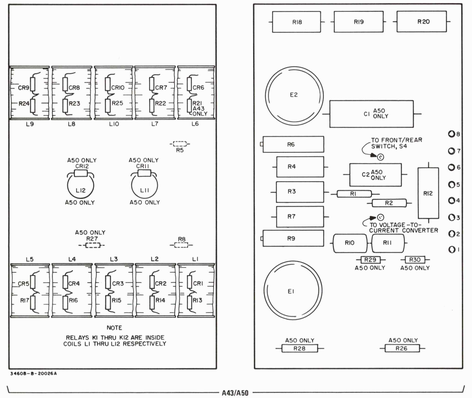
Two transistorized oscillator boards have been supplied with the 3460B. The difference is in component layout. Your board is most readily identified by the position of CR2.



A5A1



A4



A43/A50

TROUBLESHOOTING A5

HALF SPLIT TROUBLESHOOTING THE DC AMP.

The DC Amplifier can be split, for troubleshooting purposes, at C13. If A5Q9 can be made to saturate or cut off by changing the bias on A5Q7, that portion of the amplifier between A5C10 and A5C13 is probably OK. Saturate A5Q9 by shorting A5R15; cut off A5Q9 by shorting A5Q7 source to gate.

LEVEL SET A5R30 should move TP1 and TP2 voltages in opposite directions. When the voltages are adjusted so that they are equal, the voltage should be about +2 V.

SIGNAL TRACING THROUGH THE DC AMP.

After splitting, the DC amplifier can be further checked by following the chopper waveforms through the amplifier. These waveforms can be generated by shorting A5TP3 to A5TP4. To proceed:

a. Raise A5 on an extender board (hp- Part No. 5060-0049).

b. Short test point A5TP3 to A5TP4.

c. Connect a 50 kilohm variable resistor across C9.

d. Connect a scope probe between the collector of Q9 and common point ▽. Turn the variable resistor to zero ohms, back off the resistor until the amplifier Q7-Q9 starts to saturate; and return to a point below saturation. If the amplifier doesn't saturate, leave the resistor set at 50 kilohms. The waveform displayed should look like the one on the schematic. Q7 will usually amplify the input waveform by X1½ to X3 (a straight thru probe on the .01 V/cm range will probably be required at the input). Q8 will usually attenuate the waveform a bit due to the degenerative feedback through R23. The total gain between the input and the collector of Q9 will usually be between X50 and X100. Disconnect the 50 kilohm variable resistor and connect a 50-ohm variable resistor in its place. Connect scope probe to the collector of Q12. Adjust 50-ohm resistor for an output that is short of saturation (as above). Due to the tiny signal at the input of Q7, and the large amount of amplification, the signal be noisy at this point. The gain between test point 1 and test point 2 will be approximately 200. It is easy to saturate this half of the amplifier. If you don't see a gain of approximately 200, lower the input with the 50 ohm resistor and try again. The output of this stage will be unstable and hard to synchronize. The effect of this test is to provide a signal to follow through the amplifier Q10-Q12. This signal can be used to find dead transistors, shorted capacitors, etc., rather than to find a noise problem.

Excessive noise is usually a result of the chopper frequency approaching too close to a harmonic of 60 Hz (e.g. 180 Hz or 240 Hz). To check chopper frequency see below.

TROUBLESHOOTING THE AC AMP.

An overload indication will many times be caused by a malfunction of the FET's Q1 or Q2. If you suspect the hf amp, attempt to perform Paragraph 5-21 (a through h). If the hf amp remains saturated, apply the usual troubleshooting procedures for a dc amplifier while keeping A5TP3 and A5TP4 grounded, and the input cable to A5 removed. With A4R11 full cw, the voltage at A5 pin 15 should be -4 to -6 volts with respect to ▽. With A4R11 full ccw, the voltage should be +4 to +6 volts.

To check the DC voltage levels through both the DC and the hf amplifiers, short the input of the instrument and make all DC measurements with a floating voltmeter referred to ▽.

Assemblies A4 and A5 are matched; therefore, when replacing or completing checks or repairs to either or both, complete Paragraph 5-59.

TO CHECK CHOPPER FREQUENCY:

a. Short 3460B input.

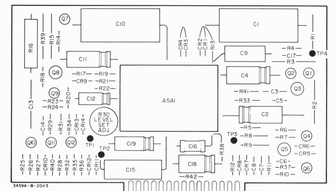
b. Connect jumper wire from A5TP3 to A5TP4.

c. Connect Electronic Counter to TP2 using X10 probe.d. Connect Oscilloscope to TP1 or TP2 using X10 probe.

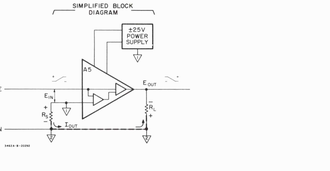
e. Frequency should be 210 +15 Hz. Check at high line and low line. If chopper frequency is near 180 Hz, DC amp will be noisy.

f. On alternate chopper assemblies (Serial No. Prefixed 925- and above) adjust R3 through access hole for exactly 210 Hz.

g. Turn 3460B off. Remove jumper leads and test equipment.



A5



FUNCTIONAL DESCRIPTION OF A5

The Voltage to Current Converter can be thought of as an operational amplifier which is so connected that it will keep the voltage difference between the lines labeled "E_{sig}" at zero. Referring to the simplified block diagram note that when a voltage appears between the input line and input common, the resulting voltage across "E_{sig}" is amplified and inverted. To generate "E_{sig}", the power amplifier draws "I_{out}" from common point ▽. If the input line goes positive, E_{sig} goes negative, draws current through R_s (the sensing resistor) and R_I in series, and causes ▽ to go positive as a result of the IR drop across R_s.

Refer to the detailed block diagram for a step by step breakdown of how A5 works. The low frequency component of "E_{sig}" is chopped and passed through the Chopper Amp as an A.C. signal. The synchronous demodulator-low pass filter changes the amplified A.C. signal to inverted d.c. and passes it to the non-inverting input of the differential amplifier. Any high frequency component of the input signal (such as transients) passes through the inverting input of the differential amplifier. Both A.C. and D.C. components of the signal are thereby inverted and again amplified. The current amplifier then draws current from common point ▽ - Common point ▽ is both the low side of the "E_{sig}" signal and the reference point of the amplifier's ±25 volt power supply. As the current amp draws current through R_s (the sensing resistor) and R_I (the input resistor) of the following stages) the IR drop across R_s will bring ▽ up to the same level as the input voltage with respect to ▽.

As an example assume that we want to measure +1.000500 volts at high with respect to low. For the first sample period the attenuator is automatically set to X0.1. One tenth of the input voltage appears across E_{sig} is converted to frequency, counted, and 1.000 volts is fed back through the D/A Converter in series with the input to A5 to null out the input voltage. For the second sample period the attenuator is automatically set to X1. The nulling effect of the D/A Converter leaves a difference of +0.0005 volts at the input to A5. The input to A5 (E_{sig}) is amplified and inverted. The current amplifier causes the output to go negative with respect to ▽. Current is drawn from ▽ through R_s and R_I towards the negative going amplifier output. ▽ therefore becomes positive with respect to ▽ until the difference (E_{sig}) between the input lines to A5 become zero. It follows then that the current through the sensing resistor (R_s) is equal to the current through the input resistance of the following stages (R_I), and proportional to the input voltage.

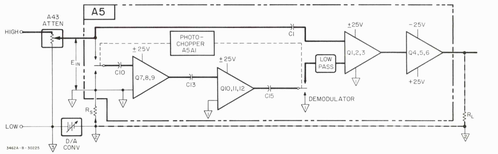


Figure 7-5. Component Location Diagrams; Assemblies A4, A5, A43 and A50

NOTES

1. VALUES IN OHMS AND MICROFARADS UNLESS OTHERWISE NOTED.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED ON A4, A5, A43 and AND A50; PREFIX WITH A4, A5, A43 AND A50 AS APPLICABLE.
3. ⏚ POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).
   ▽ A4, A5 DECK; ±25 VOLT POWER SUPPLY COMMON.
   ▽ A1, A2, A3 DECK; ±17.5 VOLT POWER SUPPLY COMMON.
   ▽ A19, A36 OR A8 DECK; REFERENCE POWER SUPPLY COMMON.
   ▽ GUARD.
4. ——————— DENOTES ETCHED CIRCUIT BOARD.
   — — — — — DENOTES COMPONENT BOARD ASSEMBLY.
   ——————— DENOTES MAIN SIGNAL PATH.
   — — — — — DENOTES FEEDBACK PATH.
5. ▭ DENOTES FRONT PANEL MARKING.
   ▭ DENOTES REAR PANEL MARKING.
   ⊘ DENOTES SCREWDRIVER ADJUST.
   918 DENOTES WIRE COLOR USING STANDARD COLOR CODE. (e.g. 918 = WHITE, BROWN, GRAY)

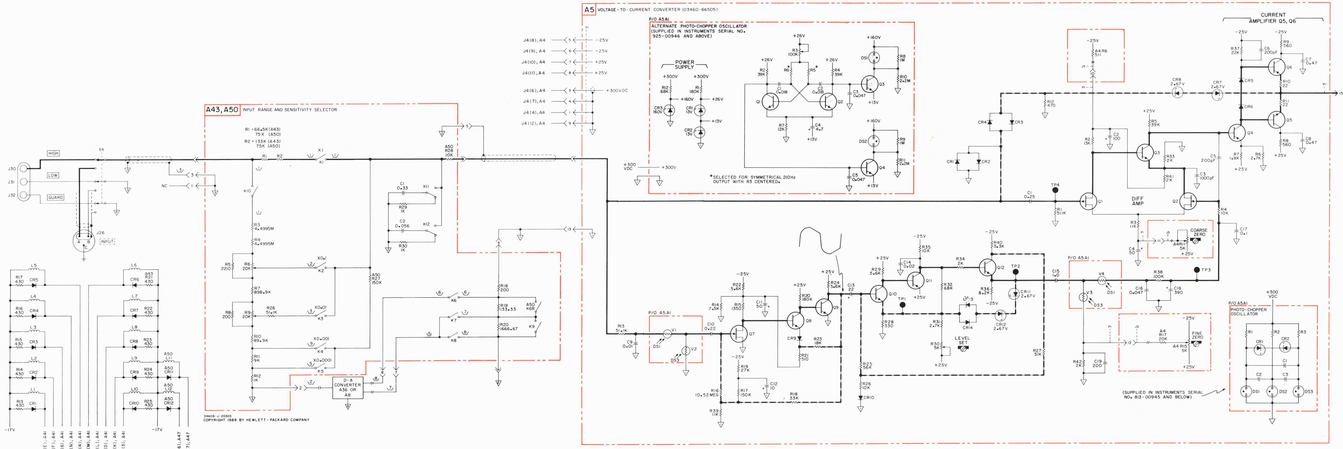


Figure 7-6. Voltage-to Current Converter; Assemblies A4, A5, A43 and A50

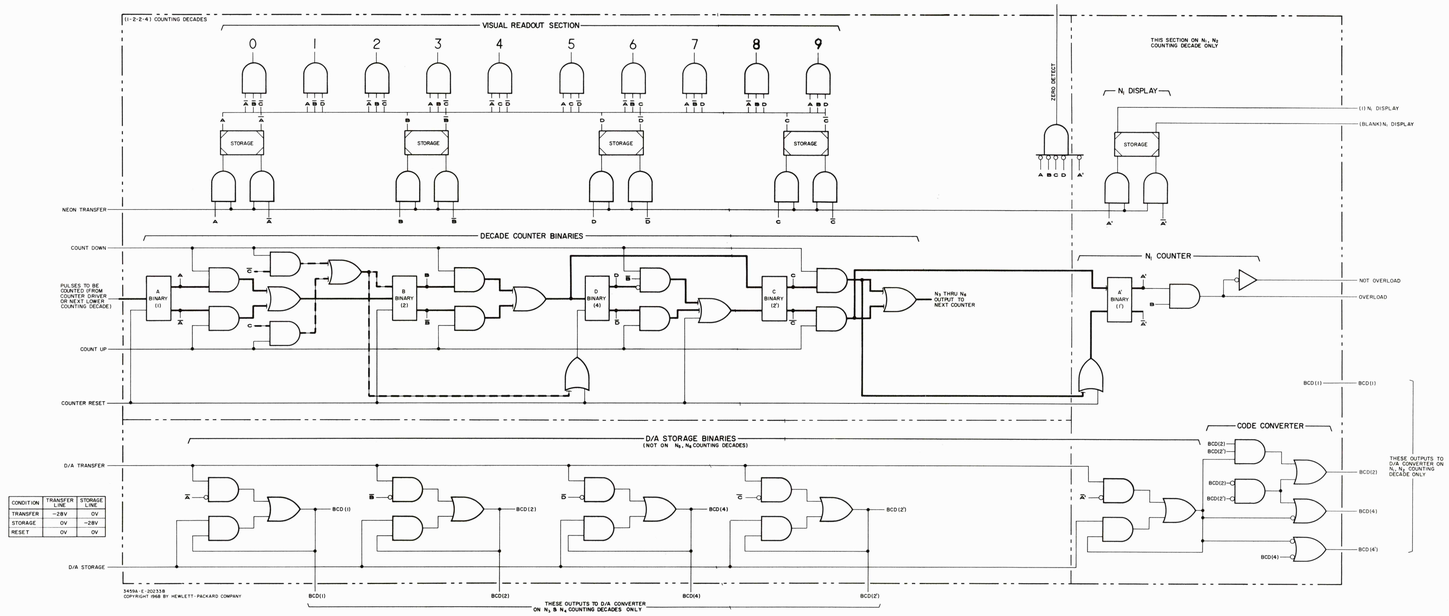
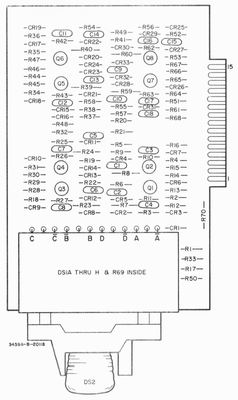


Figure 7-7. Logic Diagram, 1-2-2-4 Decade Counter



NOTES

1. VALUES IN OHMS AND PICOFARADS UNLESS OTHERWISE NOTED.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED ON A9, A10: PREFIX WITH A9, A10 AS APPLICABLE.
3. ⏚ POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).
   ⏚ GROUND ON ETCHED CIRCUIT BOARD.
4. ——— — — — DENOTES ETCHED CIRCUIT BOARD.
   ——————— DENOTES MAIN SIGNAL PATH.
   — — — — — DENOTES FEEDBACK PATH.
5. VERTICALLY ALLIGNED PHOTOCELLS ARE EXCITED BY THE LAMP DIRECTLY BELOW.
6. TO TRACE ELECTRICAL PATH FOR A LIGHTED NUMERAL IN DS2, PROCEED FROM NUMERAL THROUGH PHOTOCELLS TO -150 VOLTS. (SEE EXAMPLE FOR NUMERAL 4.)

A9, A10 COMPONENT LOCATIONS

	C	CR	Q	R		R
1	G8	E6	G5	E6	35	F13
2	G8	E5	G6	F6	36	F13
3	G4	F4	G10	F5	37	H16
4	G7	G7	G10	F4	38	H17
5	G12	G7	G14	E7	39	G14
6	G12	H4	G15	H8	40	G15
7	G8	H4	G20	G5	41	G17
8	G11	E9	G21	G6	42	G13
9	G17	E11		G8	43	G13
10	G17	F9		G5	44	J13
11	G15	G12		G6	45	H13
12	G16	G12		J4	46	H14
13	G19	H8		B5	47	H15
14	G18	H8		B6	48	H18
15	G23	J12		B7	49	H17
16	G19	F12		B8	50	E20
17	G21	E14		E10	51	F21
18	G23	E15		F11	52	F19
19		F13		F9	53	F19
20		G16		F9	54	H18
21		G16		H12	55	H18
22		H16		H12	56	H22
23		H13		G10	57	H22
24		H13		G10	58	G17
25		E20		G13	59	G20
26		E21		G9	60	G21
27		F19		G11	61	G23
28		G16		J9	62	G19
29		G22		B9	63	G21
30		G18		H10	64	J19
31		G22		H11	65	H19
32		H19		H13	66	H20
33		H19		E14	67	H21
34				F15	68	H23

BINARY STATES REQUIRED TO LIGHT A NUMERAL

Binary A (1)	Binary B (2)	Binary C (4)	Binary D (8)	Display
$\overline{A}$	$\overline{B}$	$\overline{C}$	$\overline{D}$	0
A	$\overline{B}$	$\overline{C}$	$\overline{D}$	1
$\overline{A}$	B	$\overline{C}$	$\overline{D}$	2
A	B	$\overline{C}$	$\overline{D}$	3
$\overline{A}$	$\overline{B}$	C	$\overline{D}$	4
A	$\overline{B}$	C	$\overline{D}$	5
$\overline{A}$	B	C	$\overline{D}$	6
A	B	C	$\overline{D}$	7
$\overline{A}$	$\overline{B}$	$\overline{C}$	D	8
A	$\overline{B}$	$\overline{C}$	D	9

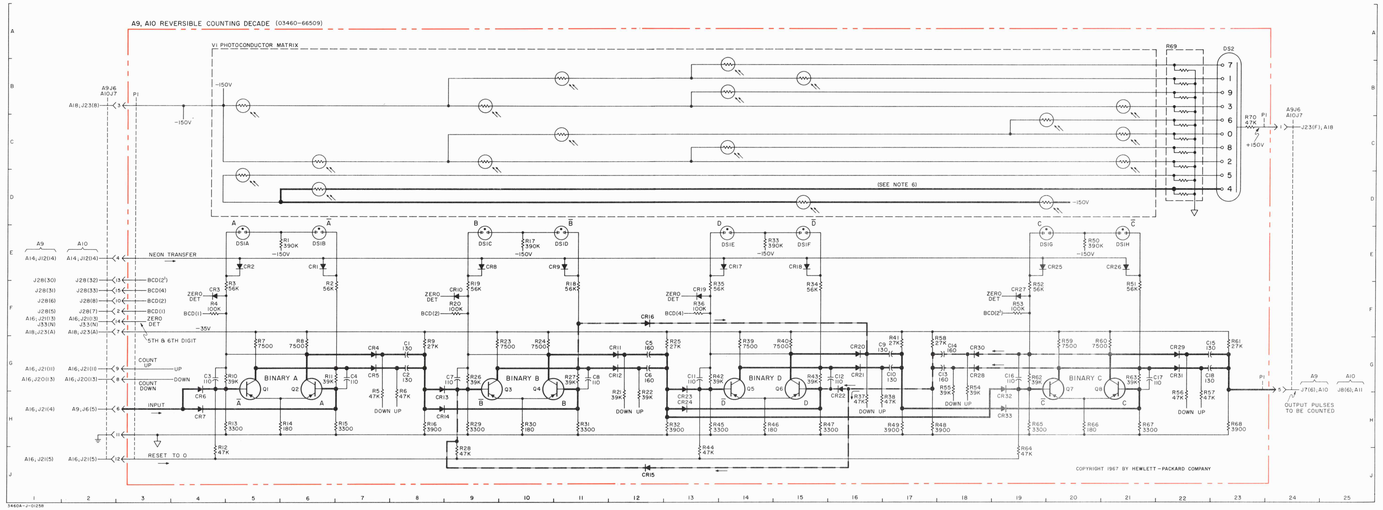
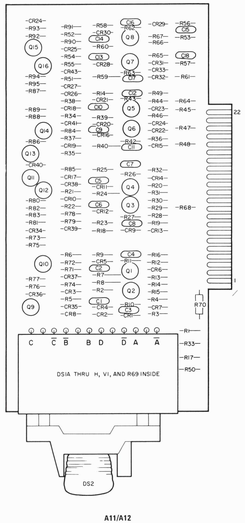


Figure 7-8. N_5 and N_6 RCD: Assemblies A9 and A10 (1-2-2-4)



NOTE: FOR LOGIC DIAGRAM SEE PAGE 7-8.

NOTES

1. VALUES IN OHMS AND PICOFARADS UNLESS OTHERWISE NOTED.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED ON A11, A12; PREFIX WITH A11, A12 AS APPLICABLE.
3. ⏚ POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).
   ▽ GROUND ON ETCHED CIRCUIT BOARD.
4. ———— DENOTES ETCHED CIRCUIT BOARD.
   ———— DENOTES MAIN SIGNAL PATH.
   — — — — DENOTES FEEDBACK PATH.
5. VERTICALLY ALLIGNED PHOTOCELLS ARE EXCITED BY THE LAMP DIRECTLY BELOW.
6. TO TRACE ELECTRICAL PATH FOR A LIGHTED NUMERAL IN DS2, PROCEED FROM NUMERAL THROUGH PHOTOCELLS TO -150 VOLTS. (SEE EXAMPLE FOR NUMERAL 4.)

A11, A12 COMPONENT LOCATIONS

C	CR	Q	R	CR	R	R	R
1	J8	G6	J5	G6	26	G21	J9	51	H21	T6	B5
2	J8	G5	J6	H6	27	H19	J11	52	H18	T7	B5
3	J4	H4	J10	H5	28	J18	L9	53	H19	T8	B11
4	J7	J7	J10	H4	29	J22	K9	54	J18	T9	A9
5	J12	J7	J14	K7	30	J18	K10	55	J18	80	A9
6	J12	K4	J15	K6	31	J22	K11	56	K22	81	B10
7	J9	K4	J20	J5	32	K19	K13	57	K22	82	B9
8	J11	G9	J23	J6	33	K19	G14	58	J17	83	B9
9	J17	G11	B7	J8	34	A5	H15	59	J20	84	B15
10	J17	H9	B6	J5	35	B6	H13	60	J21	85	A13
11	J13	J12	B11	J6	36	B6	H18	61	J23	86	A13
12	J13	J12	B10	L4	37	B4	K14	62	J19	87	B14
13	J19	K9	B18	K5	38	A9	K16	63	J21	88	B13
14	J18	K9	B15	K6	39	B9	J14	64	L19	89	B13
15	J23	L12	B20	K7	40	A14	J15	65	K19	90	B20
16	J19	H12	B19	K8	41	B13	J17	66	K20	91	A18
17	J21	G14		G10	42	A18	J13	67	K21	92	A18
18	J23	G15		H11	43	B18	J15	68	K23	93	B19
19		H13		H9	44		L12	69	C22	94	B18
20		J16		H5	45		K13	70	E23	95	B18
21		J16		K12	46		K14	71	B8		
22		K16		K12	47		K15	72	A4		
23		K15		J10	48		K17	73	B4		
24		K13		J10	49		K17	74	B7		
25		G20		J13	50		G20	75	B5		

BINARY STATES REQUIRED TO LIGHT A NUMERAL

Binary A (1)	Binary B (2)	Binary C (4)	Binary D (8)	Display
A	B	C	D	0
Ā	B	C	D	1
A	B̄	C	D	2
Ā	B̄	C	D	3
A	B	C̄	D	4
Ā	B	C̄	D	5
A	B̄	C̄	D	6
Ā	B̄	C̄	D	7
A	B	C	D̄	8
Ā	B	C	D̄	9

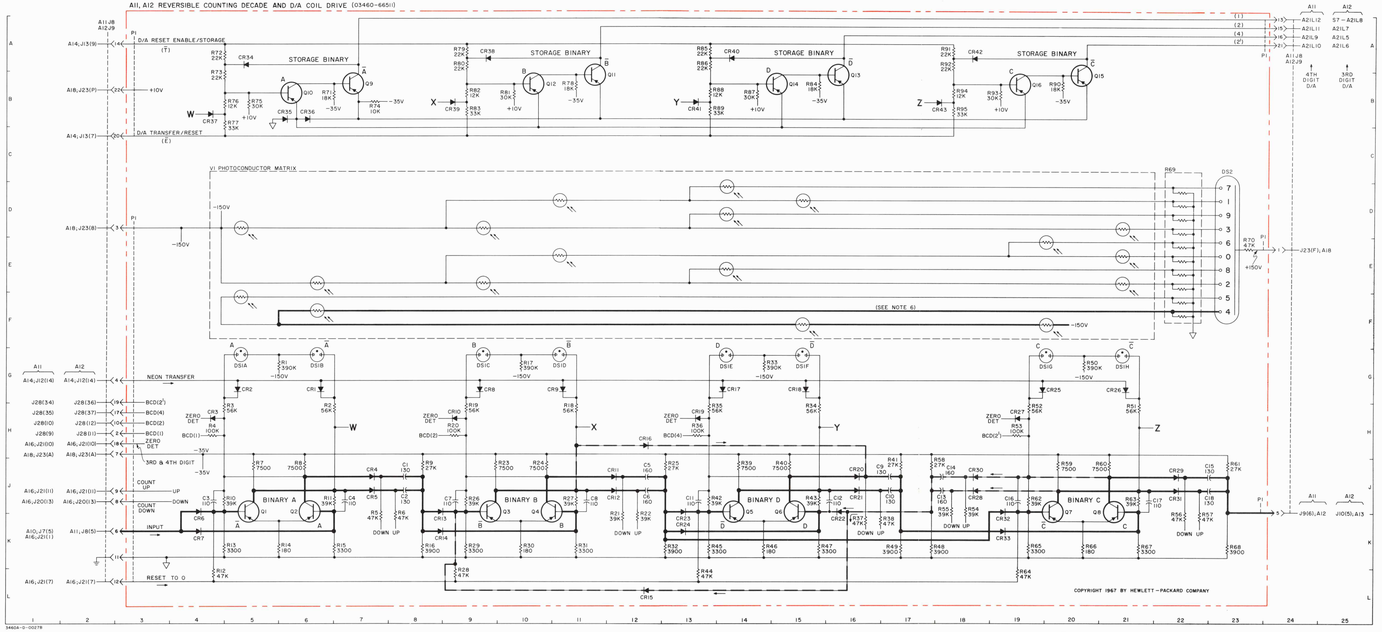
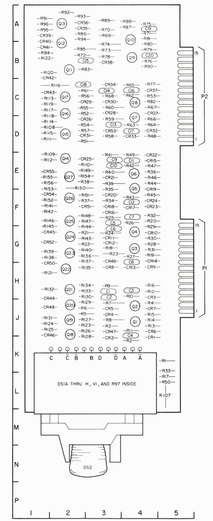


Figure 7-9. N_3 and N_4 RCD/D-to-A Coil Drive; Assemblies A11 and A12 (1-2-2-4)

A13 ASSEMBLY COMPONENT LOCATIONS

	C	CR	Q	R		CR	R		R		R		R
1	H3	K4	J4	K5	30	C3	G4	59	D3	88	A4	122	B1
2	H3	K3	J4	K4	31	D2	G4	60	C3	89	A3	123	J2
3	H4	H6	G4	J3	32	D4	F4	61	C2	90	B4	124	J1
4	J4	J3	G4	J4	33	D4	K5	62	C4	91	A1	125	J1
5	F3	J3	E4	J2	34	C3	F3	63	D4	92	A2	126	J2
6	F3	J4	E4	J2	35	A2	F3	64	D4	93	A2	127	J2
7	F4	J4	D4	J3	36	A2	E4	65	C4	94	A2	128	J2
8	G4	H3	C4	J3	37	C4	F2	66	D4	95	A1	129	J2
9	E3	H4	B4	H3	38	B3	E2	67	C4	96	A1	130	H2
10	E3	G4	A4	H4	39	A1	E3	68	C3	97	L3	131	J1
11	E4	F3	B2	J4	40	A1	E3	69	A3	98		132	H1
12	F4	F3	B2	H4	41	B1	E3	70	A3	99		133	H2
13	D3	H4	A2	J4	42	B1	E4	71	A4	100		134	H2
14	C3	G4	E2	J4	43	C1	F4	72	B2	101		135	H2
15	B2	E4	D2	J4	44	H1	E4	73	B3	102		136	G2
16	C4	F3	C2	H4	45	G1	F4	74	B3	103		137	G2
17	D4	F4	C2	K5	46	J1	E4	75	A4	104		138	G1
18	C2	F3	J2	F3	47	J3	E4	76	B4	105		139	G1
19	A4	F4	J2	G4	48	J1	D4	77	C4	106		140	G2
20	B4	F3	J2	F4	49	F3	E4	78	B3	107	K5	141	F1
21		E3	A2	G2	50	H1	K5	79	B4	108	D3	142	F1
22		E4	H2	G2	51	F2	D2	80	B4	109	E1	143	G2
23		F4	G2	F3	52	G1	C2	81	A4	110	E2	144	G2
24		F4	G2	F3	53	D3	C4	82	C4	111	D1	145	G1
25		E2	F2	F3	54	F1	D2	83	B2	112	E1	146	F1
26		D2	F2	F4	55	E1	C2	84	B1	113	C1	147	F2
27		C4	E2	G4	56		C2	85	B2	114	D1	148	F2
28		C3		G4	57		D2	86	A2	115	D1	149	E2
29		C2		G4	58		D3	87	A4	116	C2	150	E2
										117	C1	151	F2
										118	D1	152	F1
										119	C1	153	E1
										120	B1	154	E2
										121	H1	155	E1
												156	E1



NOTE: FOR LOGIC DIAGRAM SEE PAGE 7-8.

Figure 7-10. Component Location Diagram; Assembly A13 (1-2-2-4)

NOTES

1. VALUES IN OHMS AND MICROFARADS UNLESS OTHERWISE NOTED.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED ON A13; PREFIX WITH A13.
3. ⏚ POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).
   ⏚ GROUND ON ETCHED CIRCUIT BOARD.
4. ——— DENOTES ETCHED CIRCUIT BOARD.
   ——— DENOTES MAIN SIGNAL PATH.
   - - - - DENOTES FEEDBACK PATH.
5. VERTICALLY ALLIGNED PHOTOCELLS ARE EXCITED BY THE LAMP DIRECTLY BELOW.
6. TO TRACE ELECTRICAL PATH FOR A LIGHTED NUMERAL IN D02, PROCEED FROM NUMERAL THROUGH PHOTOCELLS TO -150 VOLTS. (SEE EXAMPLE FOR NUMERAL 4)

A13 COMPONENT LOCATIONS

C	CR	Q	R		CR	R		R		R
1	J7	G6	K5	G5	40	K29	J14	79	K24	118	C27
2	J7	G4	K5	H6	41	L29	J16	80	K23	119	C27
3	J4	H4	K9	H4	42	C26	J13	81	K25	120	B27
4	J6	J7	K10	H4	43	C26	J15	82	L26	121	A27
5	J12	J7	K14	K7	44	C5	L15	83	J30	122	B27
6	J12	K4	K14	K7	45	C6	K15	84	J29	123	B6
7	J9	K4	K20	J5	46	B4	K14	85	J28	124	B4
8	J11	G9	K20	J5	47	C4	K15	86	K27	125	B4
9	J16	G10	K24	J8	48	B9	K17	87	K27	126	C4
10	J16	H8	K25	J4	49	C8	K18	88	K28	127	C5
11	J15	J11	K29	J4	50	C10	G20	89	K26	128	C4
12	J15	J11	K28	L4	51	C13	H21	90	K30	129	B9
13	J17	K8	K27	K4	52	B15	H19	91	K28	130	B10
14	J17	K8	D29	K5	53	C17	H19	92	K27	131	B6
15	J22	L12	D27	K6	54	B23	K18	93	J26	132	B8
16	J19	H12	C27	K8	55	C22	K17	94	J30	133	B9
17	J21	G13	D27	G10	56		K22	95	K28	134	B9
18	J22	G15	D6	H10	57		K22	96	K27	135	C9
19	J23	H13	B5	H9	58		J17	97	C21	136	B14
20	J26	J16	B11	H8	59		J19	98	NA	137	B15
21		J16	B10	K11	60		J20	99	NA	138	B13
22		K15	B15	K12	61		J22	100	NA	139	B13
23		K12	B14	J9	62		J19	101	NA	140	B14
24		K13	B20	J10	63		J21	102	NA	141	B13
25		G20	B19	J12	64		L19	103	NA	142	C13
26		G19	H24	J9	65		K19	104	NA	143	B16
27		H19	B23	J10	66		K20	105	NA	144	B19
28		J18		L8	67		K21	106	NA	145	B17
29		J21		K9	68		K22	107	B23	146	B17
30		J18		K10	69		H24	108	D28	147	B18
31		J21		K11	70		H25	109	C28	148	B17
32		K18		K12	71		H26	110	D28	149	C11
33		K16		G14	72		J23	111	D28	150	B23
34		K23		H15	73		J24	113	D25	151	B24
35		G24		H13	74		J25	113	D26	152	B22
36		G25		H15	75		J24	114	D26	153	B22
37		K23		K16	76		J25	115	D26	154	B23
38		K23		K16	77		H24	116	C26	155	B22
39		K29		J14	78		K25	117	B27	156	C22

BINARY STATES REQUIRED TO LIGHT THE FIRST AND SECOND DIGIT NUMERALS

Binary A (1)	Binary B (2)	Binary C (2²)	Binary D (4)	Display
A'	A	B	C	D	= 0
A	A	B	C	D	= 1
A'	A	B	C	D	= 2
A	A	B	C	D	= 3
A'	A	B	C	D	= 4
A	A	B	C	D	= 5
A'	A	B	C	D	= 6
A	A	B	C	D	= 7
A'	A	B	C	D	= 8
A	A	B	C	D	= 9
A'	A	B	C	D	= 10
A'	A	B	C	D	= 11

BINARY STATES REQUIRED TO LIGHT FIRST DIGIT NUMERAL

BINARY A (1)	BINARY B (2)	BINARY C (2²)	BINARY D (4)	DISPLAY
A'	A	B	C	D	= —
A	A	B	C	D	= 1
		OR		
A'	A	B	C	D	= 1
A	A	B	C	D	= OVLD

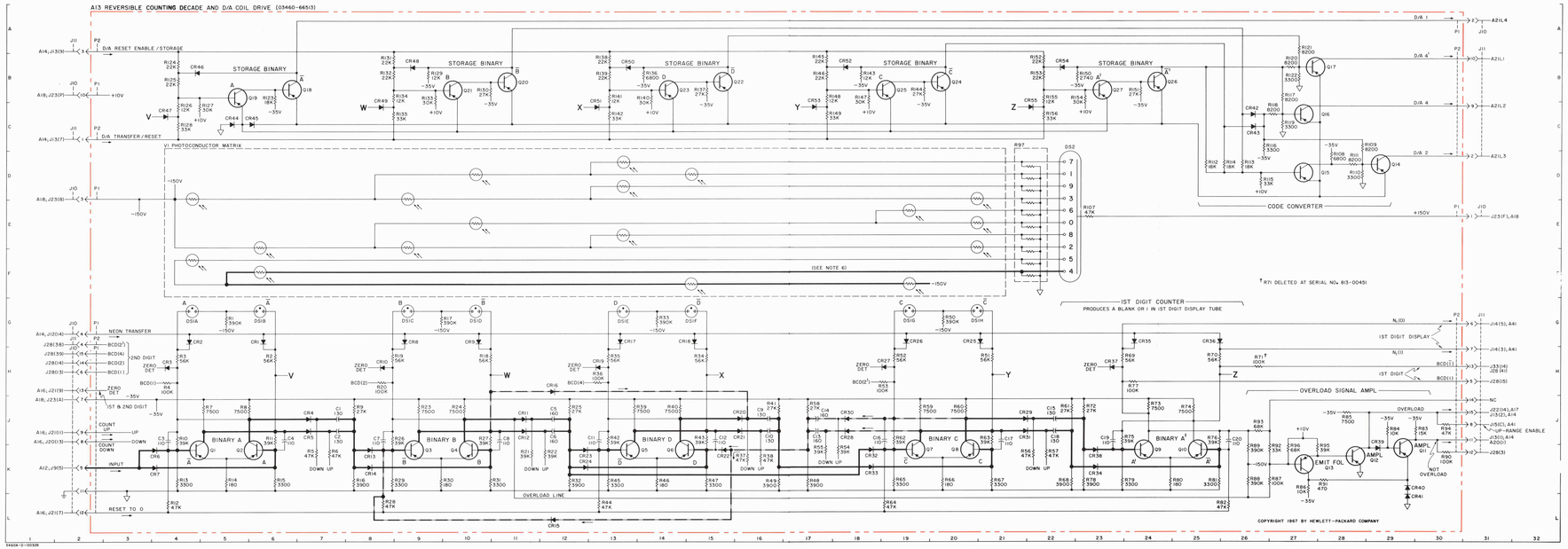
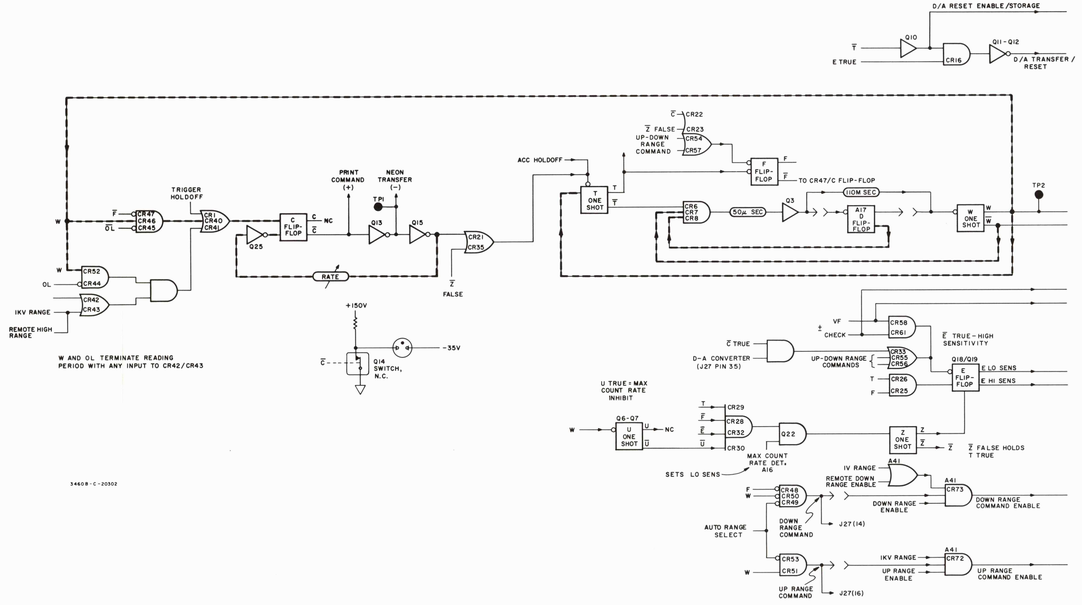


Figure 7-11. N_1 and N_2 RCD/D-to-A Coil Drive; Assembly A13 (1-2-2-4)



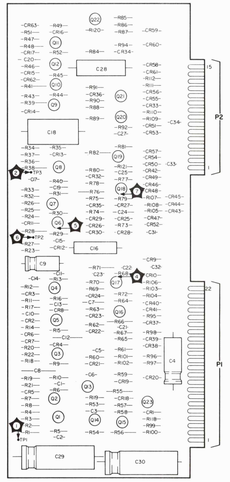


Figure 7-12. Block Diagram; Assembly A14

NOTES

1. VALUES IN OHMS AND MICROFARADS UNLESS OTHERWISE NOTED.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED ON A14, A20; PREFIX WITH A14, A20 AS APPLICABLE.
3. ⏚ POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).
   ⏚ GROUND ON ETCHED CIRCUIT BOARDS.
4. ——— DENOTES ETCHED CIRCUIT BOARD.
   ——— DENOTES MAIN SIGNAL PATH.
   ——— DENOTES FEEDBACK PATH.
   ▭ DENOTES FRONT PANEL MARKING.
   ▭ DENOTES REAR PANEL MARKING.
5. DENOTES WIRE COLOR USING STANDARD COLOR CODE. (e.g., 918 = WHITE, BROWN, GRAY).

A14 COMPONENT LOCATIONS

	C	CR	Q	R		CR	R		R
1	E9	F7	F10	F32	41	F7	D20	81	J24
2	E10	E24	F8	E10	42	E5		82	H29
3	E12	D25	F23	F10	43	F5	F20	83	
4	F15	F23	E28	F10	44	E5	B28	84	K20
5	G21	F21	E30	F10	45	D5	B29	85	J19
6	B14	E21	J15	J9	46	D5	B27	86	J20
7	B14	E21	J17	E8	47	D5	C29	87	J20
8	F22	E31	E20	E23	48	K29	C27	88	J23
9	F22	E31	E20	E23	49	K29	C27	89	J21
10	E27	G31	B28	E24	50	K29		90	J23
11	E27	K14	C29	E25	51	E27	C29	91	J24
12	E29	A16	B30	D28	52	E27	C30	92	J22
13	F29	F17	F12	E29	53	K29	E11	93	
14	K13	E17	G12	D30	54	C18	G12	94	J23
15	J15	B27	F14	E30	55	H22	E12	95	G7
16	J17	C28	B22	E19	56	H22	E14	96	H7
17	F19	K25	B24	D25	57	B18	D12	97	H8
18	E17	E12	H27	E23	58	H25	F14	98	G8
19	E19	F15	H28	F21	59	G25	F15	99	H8
20	B28	F15	J21	E22	60	G25	C15	100	H9
21	B22	E16	J23	F22	61	G25	B15	101	G22
22	B24	B18	J20	E22	62	F19	B16	102	G21
23	C21	B18	H8	K13	63	C29	C16	103	C6
24	J25	C22		K13	64		C23	104	E6
25	J27	H24		K14	65		C23	105	F6
26	NA	H24		K14	66		A22	106	D6
27	J22	H26		J16	67		B22	107	C6
28	J23	J18		I15	68		B24	108	E6
29	J6	K18		J15	69		C23	109	B17
30	J6	J18		J17	70		B24	110	C17
31	D6	NA		K16	71		A24	111	C16
32	E6	K18		K16	72		C23	112	B16
33	C14	C22		J17	73		H25	113	NA
34	B14	J21		F17	74		I25	114	NA
35		F16		F17	75		H25	115	NA
36		I23		F18	76		H27	116	NA
37		G7		F18	77		H27	117	NA
38		H7		D18	78		H28	118	I8
39		H9		E17	79		I27	119	G12
40		E7		E19	80		I28	120	J19
								121	I28

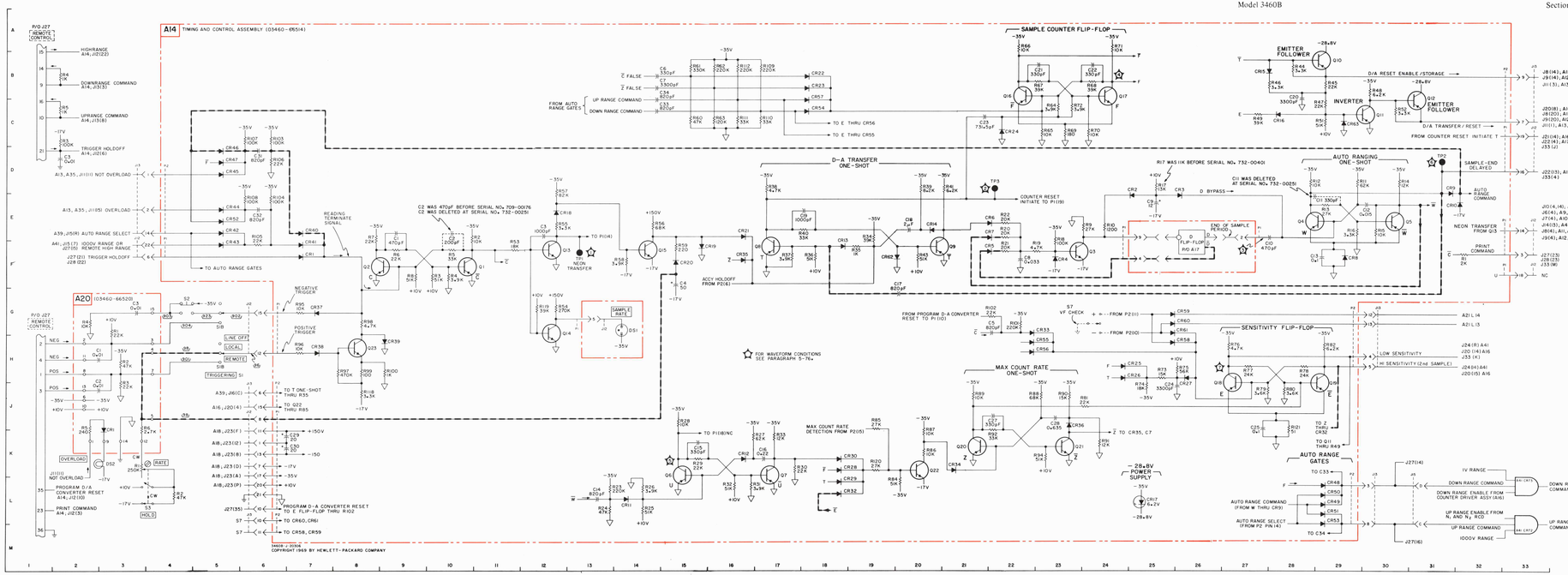


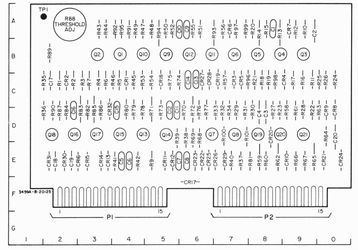
Figure 7-13. Timing and Control; Assemblies A14 and A20

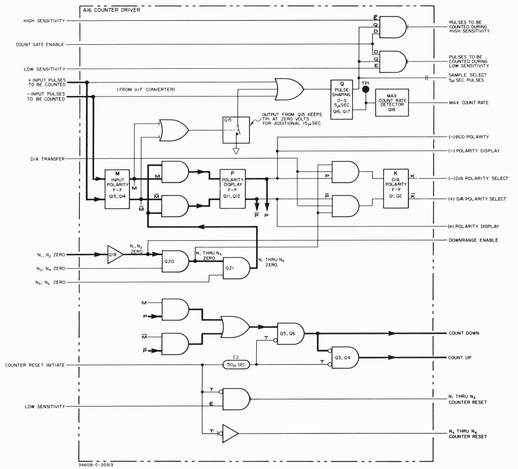
A16 ASSEMBLY COMPONENT LOCATIONS

	C	CR	Q	R		R		R
1	A8	C4	B4	C2	36	D2	71	D5
2	A9	C2	B3	C2	37	E7	72	D6
3	D8	C7	B9	C3	38	D6	73	D5
4	D8	C9	B8	C3	39	D5	74	C5
5	E4	C7	B6	C4	40	E7	75	C5
6	E4	A7	B7	C3	41	E4	76	D6
7	E5	A9	D6	C3	42	E4	77	D6
8	E6	D0	D7		43	A3	78	D4
9	A6	D0	B5	E5	44	A3	79	D4
10	A5	E9	B4	A9	45	C4	80	D4
11	D5	E5	B6	C9	46	C4	81	E8
12	D5	E5	B6	A9	47	A4	82	D3
13	C6	E3	D4	A8	48	A5	83	D3
14	C6	E3	D5	A8	49	A4	84	D2
15	D4	E3	D4	A8	50	A5	85	D3
16	D2	E2	D2	C9	51	A6	86	D3
17	C2	F6	D3	C9	52	A5	87	D2
18	E2	C5	D2	C8	53	C4	88	A2
19	E2	C7	D8	C8	54	C5	89	B2
20	D0	D8	D8	A8	55	A6	90	D2
21		E0	D9	C8	56	A7	91	A4
22		E6		D9	57	C7	92	A4
23		E6		D8	58	D9	93	A6
24		E0		C0	59	E8	94	A5
25		E6		C0	60	E8	95	A4
26		E7		D7	61	D9	96	C7
27		C6		D8	62	E8	97	A7
28		C6		D9	63	D0	98	C8
29		E7		D7	64	D0	99	A7
30		E2		D8	65	E9	100	D7
31		E2		D7	66	E9	101	D7
32		D3		D7	67	E9		
33				D7	68	D6		
34				D7	69	D6		
35				C2	70	D6		

NOTES

1. VALUES IN OHMS AND PICOFARADS UNLESS OTHERWISE NOTED.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED ON A16; PREFIX WITH A16.
3. ⏚ POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).
   ▽ GROUND ON ETCHED CIRCUIT BOARD.
4. ——— DENOTES ETCHED CIRCUIT BOARD.
   ——— DENOTES MAIN SIGNAL PATH.
5. ⊘ DENOTES SCREWDRIVER ADJUST.





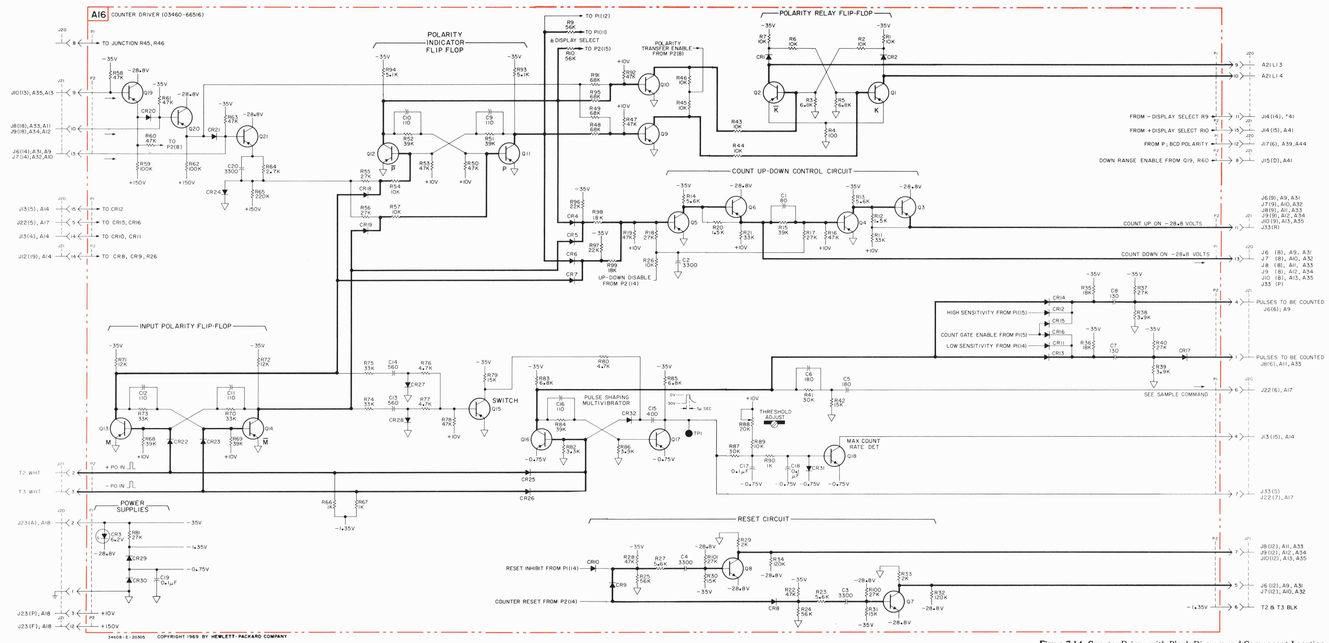


Figure 7-14. Counter Driver, with Block Diagram and Component Location Diagram; Assembly A16

NOTES

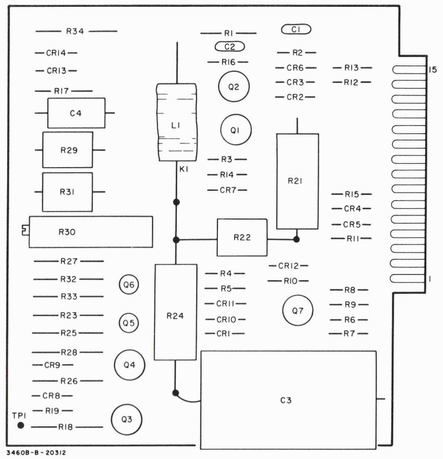
1. VALUES IN OHMS AND MICROFARADS UNLESS OTHERWISE NOTED.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED ON A17; PREFIX WITH A17.
3. ⏚ POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).

   ▽ GROUND ON ETCHED CIRCUIT BOARD.
4. ——— — — — DENOTES ETCHED CIRCUIT BOARD.

   ——— DENOTES MAIN SIGNAL PATH.

   — — — DENOTES FEEDBACK PATH.

   ⊘ DENOTES SCREWDRIVER ADJUST.



A17

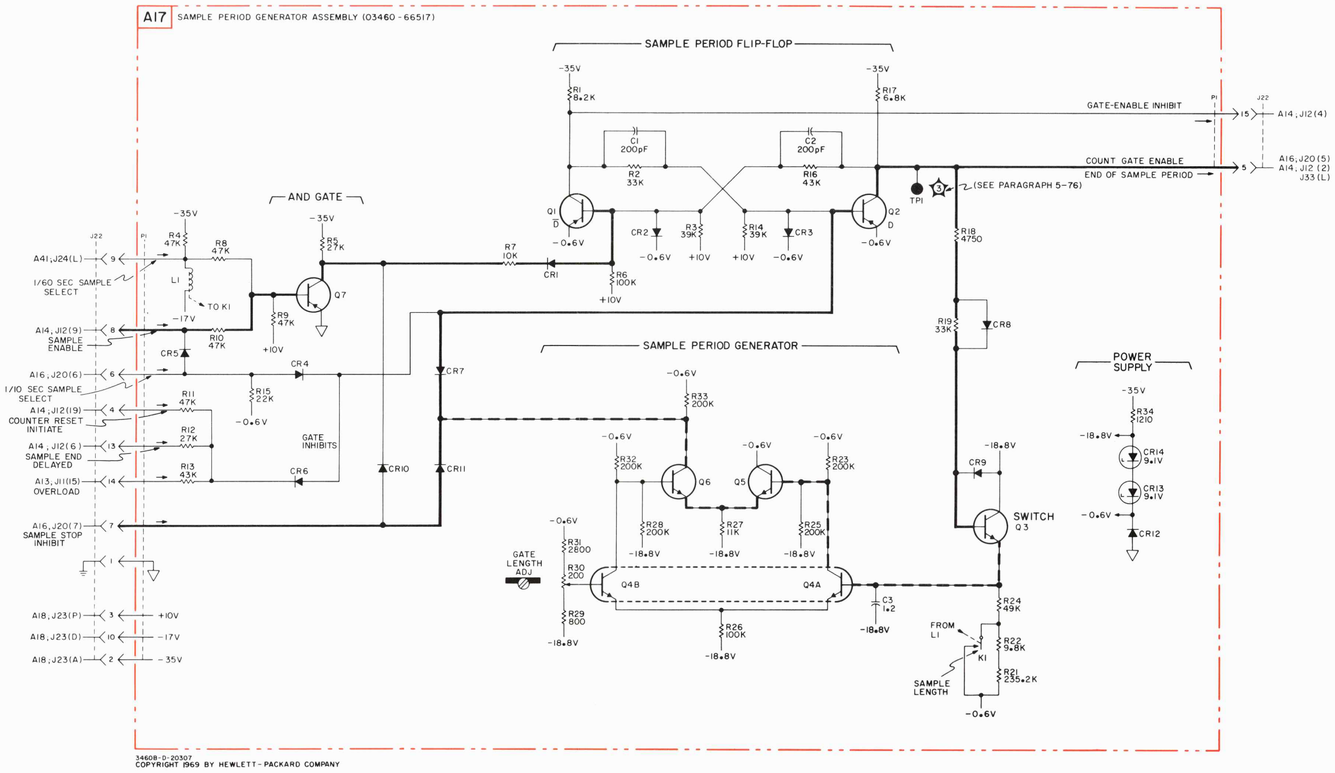


Figure 7-15. Sample Period Generator; Assembly A17

NOTES

1. VALUES IN OHMS AND MICROFARADS UNLESS OTHERWISE NOTED.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED ON A18; PREFIX WITH A18.
3. ⏚ POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).

   ▽ GROUND ON ETCHED CIRCUIT BOARD.

   ▽ A4, A5 DECK; ±25 VOLT POWER SUPPLY COMMON.

   ▽ A1, A2, A3 DECK; ±17.5 VOLT POWER SUPPLY COMMON.

   ▽ A19, A36 OR A8 DECK; REFERENCE POWER SUPPLY COMMON.

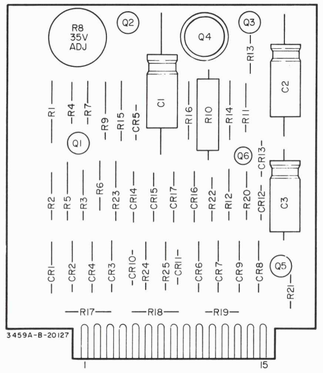
   ▽ GUARD.
4. ——— DENOTES ETCHED CIRCUIT BOARD.

   ——— DENOTES MAIN SIGNAL PATH.

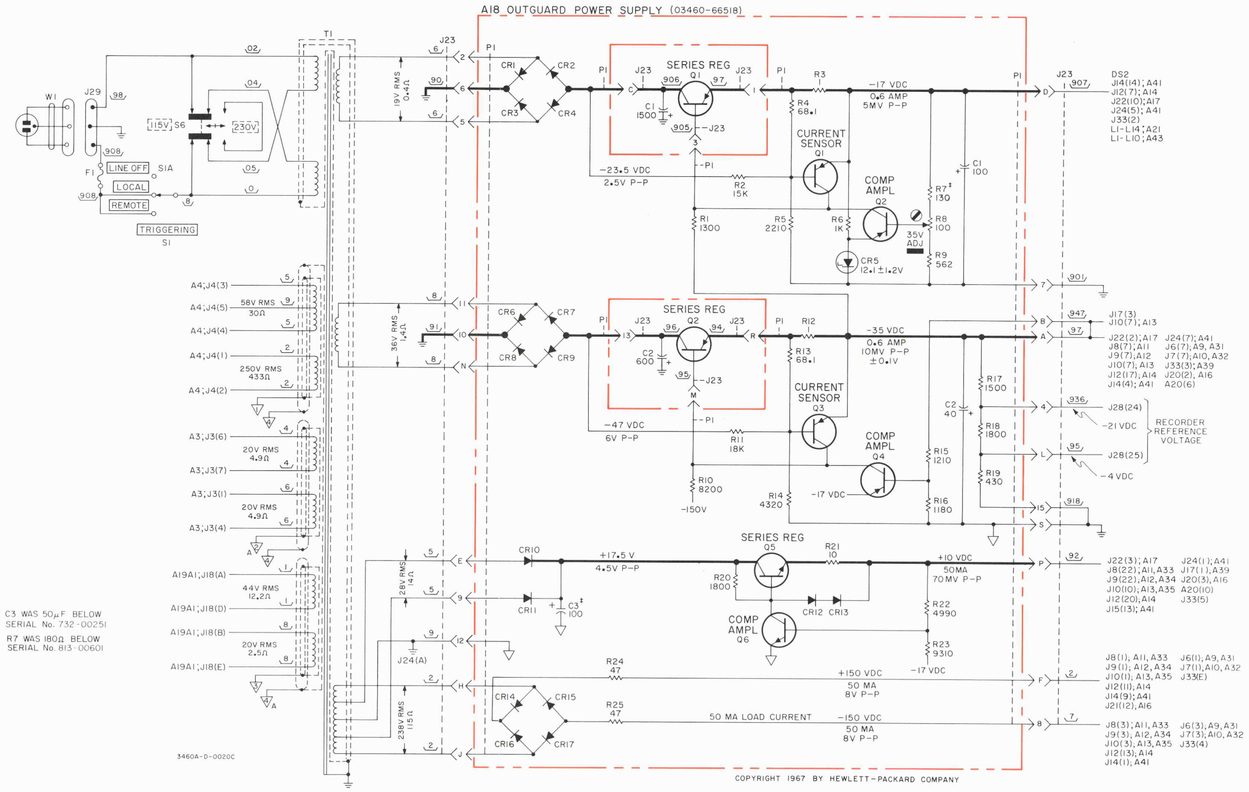
   ▭ DENOTES FRONT PANEL MARKING.

   ▭ DENOTES REAR PANEL MARKING.

   ⊘ DENOTES SCREWDRIVER ADJUST.
5. 918 DENOTES WIRE COLOR USING STANDARD COLOR CODE. (e.g. 918 = WHITE, BROWN, GRAY).
6. UNTERMINATED T1 WINDINGS ARE REPEATED ON INDICATED SCHEMATICS.
7. T1 WINDING VOLTAGES ARE WITH LOAD.
8. T1 WINDING RESISTANCES ARE WITHOUT LOAD.
9. VOLTAGES MEASURED FROM POWER LINE GROUND.
10. RIPPLE VOLTAGES ARE TYPICAL; MAXIMUM MAY BE TWICE INDICATED LEVEL.

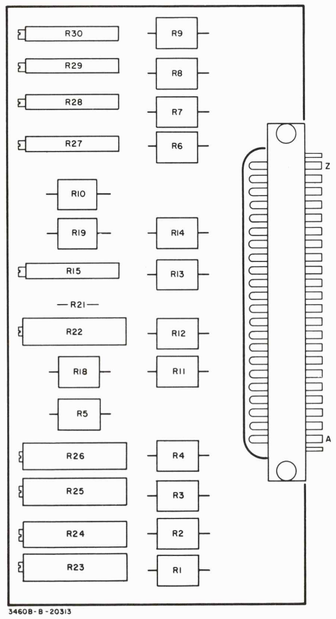


A18

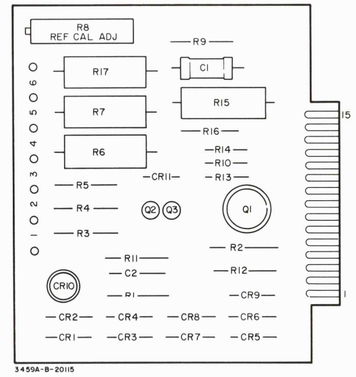


‡ C3 WAS 50μF BELOW SERIAL No. 732-00251
R7 WAS 180Ω BELOW SERIAL No. 813-00601

Figure 7-16. Out Guard Power Supply; Assembly A18



A36/A8



A19A1

CAUTION

DO NOT ADJUST ANY RESISTORS ON THE D-TO-A RESISTOR ASSEMBLY (A36 OR A8) EXCEPT R22 AS OUTLINED IN SECTION V. ALL OTHER ADJUSTMENTS ON THE D-TO-A RESISTOR ASSEMBLY ARE FACTORY ADJUSTMENTS ONLY AND ARE NOT REQUIRED FOR FIELD CALIBRATION. REFER TO THE D-TO-A CONVERTER ACCURACY AND LINEARITY CHECK IN SECTION V TO VERIFY PROPER OPERATION OF THE D-TO-A RESISTOR ASSEMBLY.

DO NOT TOUCH COMPONENTS OR CONNECTORS ON THE A36 OR A8 ASSEMBLY UNLESS CLEAN RUBBER GLOVES ARE WORN. LEAKAGE PATHS CAUSED BY FINGERPRINTS AND/OR DIRT WILL REDUCE PERFORMANCE AND ACCURACY.

NOTE

THE A36 ASSEMBLY IS USED WITH 1-2-4-8 BCD OUTPUT.

THE A8 ASSEMBLY IS USED WITH 1-2-2-4 BCD OUTPUT.

WHEN REPLACING THE MATCHED RESISTOR SET R1 THROUGH R14 ON D-TO-A RESISTOR ASSEMBLY, R9 (99.9K OHMS) IS DISTINGUISHED FROM R4 (99.9K OHMS) WITH A WHITE DOT.

Figure 7-17. Component Location Diagrams; Assemblies A19, A21, A36 or A8

NOTES

1. VALUES IN OHMS AND MICROFARADS UNLESS OTHERWISE NOTED.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED ON A8, A19, A19A1, A19A2, AND A36; PREFIX WITH A8, A19, A19A1, A19A2, AND A36 AS APPLICABLE.
3. ⏚ POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).
   ▽ A19, A36 OR A8 DECK; REFERENCE POWER SUPPLY COMMON.
   ▽ GUARD.
4. ——— DENOTES ETCHED CIRCUIT BOARD.
   — — — DENOTES COMPONENT BOARD ASSEMBLY.
   ——— DENOTES MAIN SIGNAL PATH.
   — — — DENOTES FEEDBACK PATH.
   [ ] DENOTES REAR PANEL MARKING.
   DENOTES SCREWDRIVER ADJUST.
   916 DENOTES WIRE COLOR USING STANDARD COLOR CODE. (e. g. 918 = WHITE, BROWN, GRAY)
5. LENGTH SELECTED TO OBTAIN NOMINAL LOAD REGULATION.
6. SHUNTED TO OBTAIN PROPER OUTPUT VOLTAGE ACROSS A19C2. (SEE NOTE 8)
7. REFERENCE POWER SUPPLY AND OVEN TEST JACK.
8. REFERENCE POWER SUPPLY VOLTAGE FOR 1-2-4-8 ONLY. THE REFERENCE POWER SUPPLY OUTPUT IS ADJUSTED TO 13.300 VOLTS FOR 1-2-2-4 CODED INSTRUMENTS.

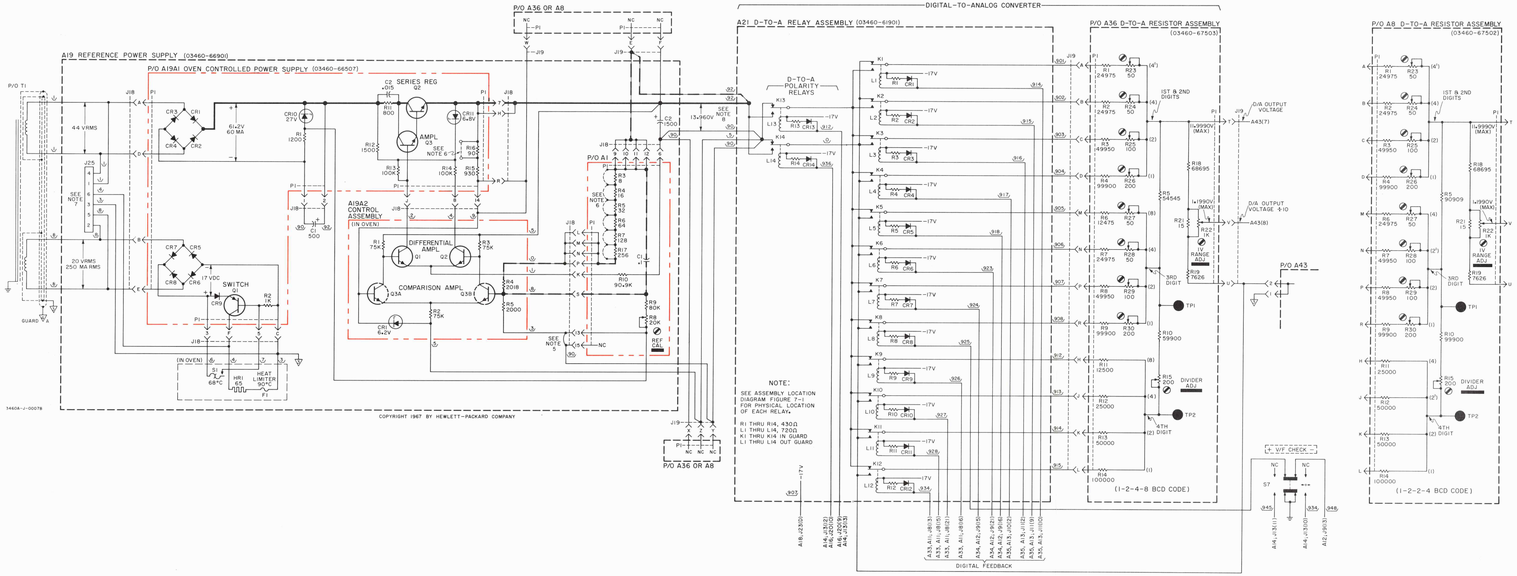
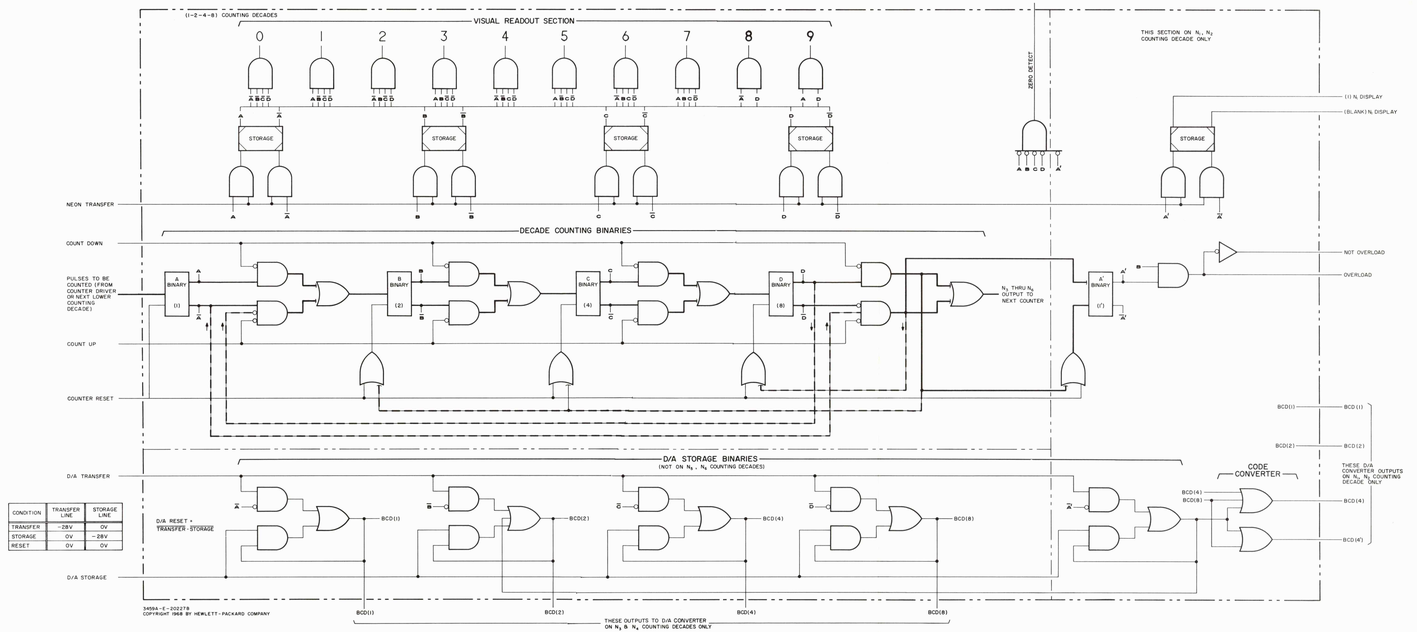
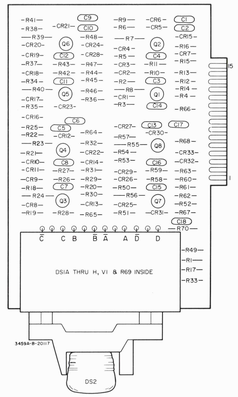


Figure 7-18. Reference Supply and D-to-A Converter; Assemblies A19, A21, A36 or A8



CONDITION	TRANSFER LINE	STORAGE LINE
TRANSFER	−28V	0V
STORAGE	0V	−28V
RESET	0V	0V

Figure 7-19. Logic Diagram 1-2-4-8 Counter



A31/A32

NOTES

1. VALUES IN OHMS AND PICOFARADS UNLESS OTHERWISE NOTED.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED ON A31, A32; PREFIX WITH A31, A32 AS APPLICABLE.
3. POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).
   GROUND ON ETCHED CIRCUIT BOARD.
4. DENOTES ETCHED CIRCUIT BOARD.
   DENOTES MAIN SIGNAL PATH.
   DENOTES FEEDBACK PATH.
5. VERTICALLY ALLIGNED PHOTOCELLS ARE EXCITED BY THE LAMP DIRECTLY BELOW.
6. TO TRACE ELECTRICAL PATH FOR A LIGHTED NUMERAL IN DS2, PROCEED FROM NUMERAL THROUGH PHOTOCELLS TO -150 VOLTS. (SEE EXAMPLE FOR NUMERAL 0.)

A31, A32
COMPONENT LOCATIONS

	C	CR	Q	R		R
1	G8	E5	G6	E6	37	H16
2	G8	E6	G6	F5	38	H17
3	G5	F5	G10	F3	39	G14
4	G7	G8	G11	F5	40	G15
5	G13	G8	G14	H5	41	G17
6	G13	H4	G15	H8	42	G14
7	G9	H4	H19	G5	43	G16
8	G12	E10	H19	G6	44	J14
9	G17	E11		G9	45	H14
10	G17	F9		G5	46	H15
11	G13	G13		G7	47	H16
12	G16	G12		J5	48	H17
13	G22	H9		H5	49	E16
14	G22	H9		H6	50	F20
15	G18	F13		H7	51	F18
16	G20	J13		H9	52	F16
17	G22	E14		E10	53	H21
18	H22	E15		F11	54	H21
19		F13		F9	55	G19
20		G16		F9	56	G19
21		G16		H12	57	G22
22		H12		H13	58	G18
23		H13		G10	59	G20
24		H13		G11	60	J16
25		E18		G13	61	H18
26		F20		G9	62	H19
27		F18		G11	63	H20
28		H16		J9	64	H22
29		G21		H9	65	G23
30		G21		H10	66	G23
31		H18		H11	67	H22
32		H18		H13	68	H23
33		H20		E15	69	A31
34				F16	70	H22
35				F14	91	
36				F13	72	

BINARY STATES REQUIRED TO LIGHT NUMERAL

BINARY A (1)	BINARY B (2)	BINARY C (4)	BINARY D (8)	DISPLAY
$\bar{A}$	$\bar{B}$	$\bar{C}$	$\bar{D}$	0
A	$\bar{B}$	$\bar{C}$	$\bar{D}$	1
$\bar{A}$	B	$\bar{C}$	$\bar{D}$	2
A	B	$\bar{C}$	$\bar{D}$	3
$\bar{A}$	$\bar{B}$	C	$\bar{D}$	4
A	$\bar{B}$	C	$\bar{D}$	5
$\bar{A}$	B	C	$\bar{D}$	6
A	B	C	$\bar{D}$	7
$\bar{A}$	$\bar{B}$	$\bar{C}$	D	8
A	$\bar{B}$	$\bar{C}$	D	9

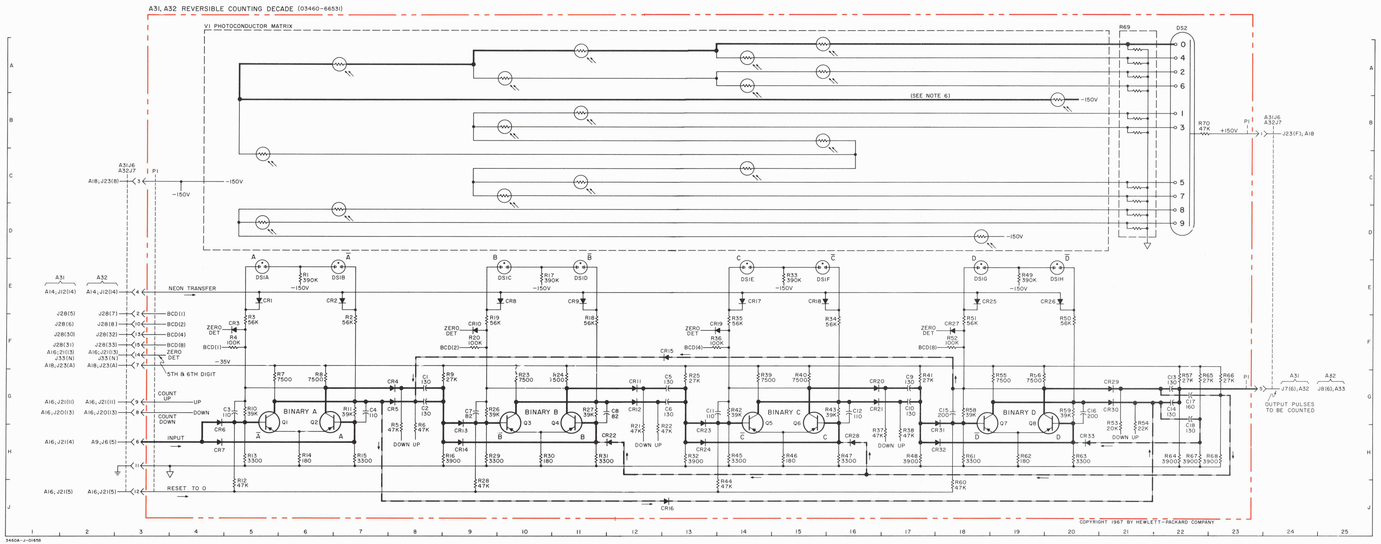
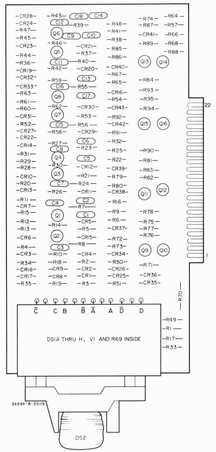


Figure 7-20. N_5 and N_6 RCD Assemblies A31 and A32 (1-2-4-8)



A33/A34

NOTE: FOR LOGIC DIAGRAM SEE PAGE 7-24.

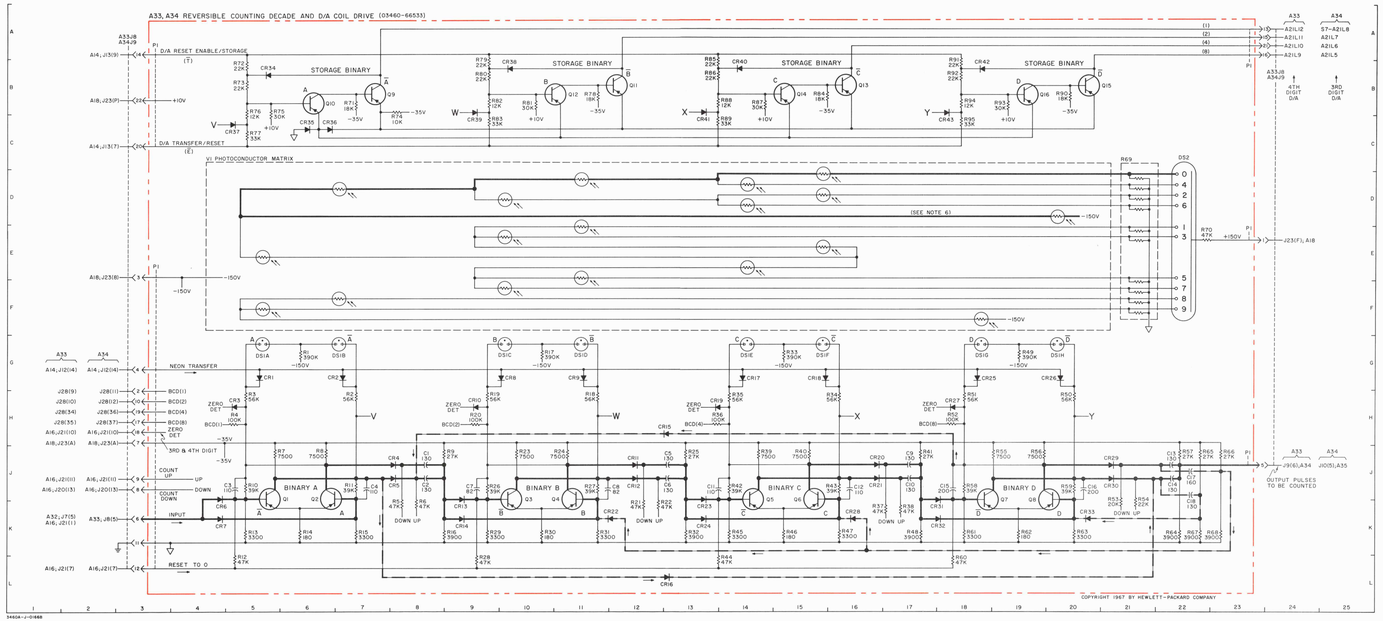
NOTES

1. VALUES IN OHMS AND PICOFARADS UNLESS OTHERWISE NOTED.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED ON A33, A34; PREFIX WITH A33, A34 AS APPLICABLE.
3. ⏚ POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).
   ▽ GROUND ON ETCHED CIRCUIT BOARD.
4. ——— DENOTES ETCHED CIRCUIT BOARD.
   ——— DENOTES MAIN SIGNAL PATH.
   — — — DENOTES FEEDBACK PATH.
5. VERTICALLY ALLIGNED PHOTOCELLS ARE EXCITED BY THE LAMP DIRECTLY BELOW.
6. TO TRACE ELECTRICAL PATH FOR A LIGHTED NUMERAL IN DS2, PROCEED FROM NUMERAL THROUGH PHOTOCELLS TO -150 VOLTS. (SEE EXAMPLE FOR NUMERAL 0.)

A33, A34 COMPONENT LOCATIONS

C	CR	Q	R	CR	R		R
1	J8	G5	J6	G6	J4	B5	R16	47	K22
2	J8	G6	J6	H7	J5	C6	R14	48	K23
3	J5	H5	J10	H5	J6	C5	R13	49	C21
4	J7	J8	J11	H5	J7	C5	K16	70	K22
5	J13	J6	K14	K8	J8	B10	K17	71	H7
6	J13	K4	K15	K8	J9	C9	J14	72	H5
7	J9	K4	K19	J6	J0	B14	J15	73	B5
8	J13	G10	K19	J6	J1	C13	J17	74	C8
9	J17	G11	B7	J9	J2	B18	J16	75	B5
10	J17	H9	B6	J5	J3	C18	J16	76	B5
11	J13	J12	B12	J7	J4		L14	77	C5
12	J16	J12	B11	L5	J5		K14	78	B11
13	J22	K9	B16	K5	J0		K15	79	B9
14	J22	K9	B15	K5	J1		K16	80	B9
15	J19	H12	B20	K7	J2		K17	81	B10
16	J20	L13	B19	K5	J3		G19	82	B9
17	J22	G14		K10	J0		G20	83	C9
18	K22	G15		B11	J1		H16	84	B15
19		H13		H9	J2		H18	85	B13
20	J16			H9	J3		K21	86	B13
21	J16			K10	J4		K21	87	B14
22	K12			K12	J5		J19	88	B14
23	K13			J10	J6		J19	89	C14
24	K13			J11	J7		J22	90	B20
25	G18			J13	J8		J18	91	B18
26	G20			J9	J9		J20	92	B18
27	H18			J11	J0		L16	93	B18
28	K16			L9	J1		K16	94	B18
29	J21			K5	J2		K19	95	C18
30	J21			K10	J3		K20	96	
31				K11	J4		K22	97	
32	K18			K13	J5		J22	98	
33	K20			G15	J6		J23	99	

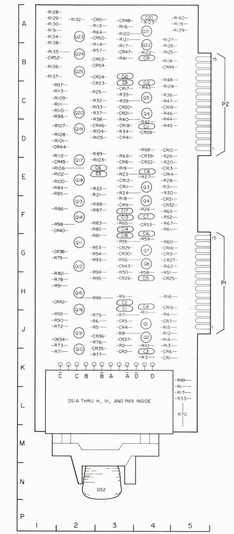
BINARY STATES REQUIRED TO LIGHT NUMERAL				
BINARY A (1)	BINARY B (2)	BINARY C (4)	BINARY D (8)	DISPLAY
$\bar{A}$	$\bar{B}$	$\bar{C}$	$\bar{D}$	0
A	$\bar{B}$	$\bar{C}$	$\bar{D}$	1
$\bar{A}$	B	$\bar{C}$	$\bar{D}$	2
A	B	$\bar{C}$	$\bar{D}$	3
$\bar{A}$	$\bar{B}$	C	$\bar{D}$	4
A	$\bar{B}$	C	$\bar{D}$	5
$\bar{A}$	B	C	$\bar{D}$	6
A	B	C	$\bar{D}$	7
$\bar{A}$	$\bar{B}$	$\bar{C}$	D	8
A	$\bar{B}$	$\bar{C}$	D	9



7-21. N_3 and N_4 RCD/D-to-A Coil Drive; Assemblies A33 and A34 (1-2-4-8)

A35 ASSEMBLY
COMPONENT LOCATIONS

	C	CR	Q	R		CR	R		R
1	H3	K4	J4	L5	49	B4	K5	97	C1
2	H3	J3	J4	J3	50	A3	G3	98	F1
3	K4	G4	E4	K4	51	A3	H4	99	H3
4	H4	J3	F4	J4	52	B1	F4	100	E1
5	E3	J3	C4	J3	53	B3	G3	101	D1
6	E3	K4	C4	J3	54	B3	G3	102	E1
7	F4	J4	G4	J3	55		G3	103	E3
8	E4	E3	G4	J3	56		G3	104	D3
9	C3	F3	J2	H3	57		B3	105	D3
10	B3	D4	K2	J4	58		H4	106	E1
11	D4	E4	2	J4	59		G4	107	D1
12	C4	E3	G2	J4	60		G4	108	D1
13	F3	E4	F2	J4	61		F4	109	C1
14	F3	E4	F2	J4	62		G4	110	C1
15	H4	H4	H2	J4	63		F4	111	C1
16	G4	G4	H2	H4	64		A3	112	D1
17	F3	C3	E2	L5	65		F3	113	C1
18	G3	D3	E2	F3	66		D3	114	B3
19	B4	C4	C2	E3	67		F4	115	A3
20	A4	C3	C2	E4	68		D4	116	A3
21		C3	A4	E3	69		L2	117	B3
22		E4	B4	E3	70		L5	118	B4
23		C3	A2	E3	71		J1	119	A5
24		B3	B2	E3	72		J1	120	A3
25		H4	B2	C3	73		J1	121	A3
26		H3		F4	74		- -	122	B4
27		G4		E4	75		J3	123	A4
28		D4		E4	76		J3	124	C4
29		G3		D4	77		J3	125	B4
30		G3		E4	78		H1	126	B4
31		F4		E4	79		G1	127	A4
32		F4		C3	80		H1	128	A1
33		F4		L5	81		G3	129	A1
34		J1		D3	82		F3	130	A1
35		J2		C3	83		F3	131	A1
36		J3		C4	84		E1	132	A2
37		J3		C3	85		E1	133	C3
38		G1		C3	86		F1	134	A1
39		D4		C3	87		F3	135	B1
40		F1		C3	88		F3	136	B1
41		D3		B3	89		D3	137	B1
42		H1		D4	90		J1	138	A1
43		G3		C4	91		H1	139	A5
44		D1		C4	92		J1	140	A5
45		E1		D4	93		G3	141	
46		D3		C4	94		H3	142	
47		B3		C4	95		H3	143	
48		A3		B4	96		C1	144	



NOTE: FOR LOGIC DIAGRAM SEE PAGE 7-24.

Figure 7-22. Component Location Diagram; Assembly A35 (1-2-4-8)

NOTES

1. VALUES IN OHMS AND PICOFARADS UNLESS OTHERWISE NOTED.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED ON A35; PREFIX WITH A35.
3. ⏚ POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).
   ⏚ GROUND ON ETCHED CIRCUIT BOARD.
4. ——— DENOTES ETCHED CIRCUIT BOARD.
   ——— DENOTES MAIN SIGNAL PATH.
   ——— DENOTES FEEDBACK PATH.
5. VERTICALLY ALLIGNED PHOTOCELLS ARE EXCITED BY THE LAMP DIRECTLY BELOW.
6. TO TRACE ELECTRICAL PATH FOR A LIGHTED NUMERAL IN DS2, PROCEED FROM NUMERAL THROUGH PHOTOCELLS TO −150 VOLTS. (SEE EXAMPLE FOR NUMERAL 0.)

A35 COMPONENT LOCATIONS

	C	CR	Q	R		CR	R		R		R
1	J7		G4	J5	G5	37	C4	K16	T3	B4	109	B26
2	J7		G6	J5	H6	38	D9	K16	T4	NA	110	D25
3	J4		H4	J9	H4	39	C9	J14	T5	C4	111	B25
4	J6		J7	J10	H4	40	B13	J14	T6	C4	112	C25
5	J12		J7	J14	K7	41	C12	J16	T7	C4	113	C26
6	J12		K4	J14	K7	42	B17	J13	T8	B10	114	J23
7	J8		K4	J18	J5	43	C17	J15	T9	B8	115	K23
8	J11		G8	J18	J5	44	B6	L13	A0	B6	116	H25
9	J16		G10	B6	J8	45	B22	K13	B1	B9	117	H24
10	J16		H8	B5	J4	46	B21	K14	S2	B9	118	H24
11	J13		J11	J11	J6	47	G24	K15	S3	C9	119	H26
12	J15		J11	D10	L4	48	G25	K16	S4	B15	120	J25
13	J21		K8	B15	K4	49	N23	G16	S5	B13	121	J24
14	J21		K6	B16	K6	50	K23	H17	S6	B13	122	J24
15	J17		H12	B19	K6	51	K20	H17	S7	B13	123	J24
16	J19		L12	B18	K8	52	J28	H17	S8	B13	124	L26
17	K31		G13	B24	G9	53	K29	K20	S9	C13	125	K25
18	J31		G15	J23	B10	54	K29	K20	S0	B19	126	K25
19	J26		H13	B26	H9	55		J18	S1	B17	127	K24
20	J23		J16	B26	H8	56		J18	S2	B17	128	K26
21			J16	K25	K11	57		J21	S3	B19	129	J26
22			K11	K24	K12	58		J17	S4	B17	130	K27
23			K12	K28	J9	59		J19	S5	C17	131	J26
24			K12	K29	J10	60		L17	S6	B7	132	J27
25			H17	K30	J12	61		K17	S7	B7	133	J28
26			G19		J9	62		K18	S6	B13	134	K27
27			H17		J10	63		K19	S9	B18	135	J33
28			K15		L8	64		K21	100	B24	136	J29
29			J20		K9	65		J22	101	B21	137	J30
30			J20		K9	66		J22	102	B21	138	K28
31			K17		K10	67		K22	103	B22	139	K30
32			K17		K13	68		K22	104	B22	140	J30
33			K19		G14	69		C20	105	C32	141	
34			D4		B15	70		K22	106	B22	142	
35			C5		B13	71		B6	107	B25	143	
36			C5		B13	72		B4	108	A25	144	

BINARY STATES REQUIRED TO LIGHT SECOND DIGIT NUMERAL

(1) BINARY A	(2) BINARY B	(4) BINARY C	(8) BINARY D	DISPLAY
$\bar{A}$	$\bar{B}$	$\bar{C}$	$\bar{D}$	$\bar{A}^1$ = 0
A	$\bar{B}$	$\bar{C}$	$\bar{D}$	$\bar{A}^1$ = 1
$\bar{A}$	B	$\bar{C}$	$\bar{D}$	$\bar{A}^1$ = 2
A	B	$\bar{C}$	$\bar{D}$	$\bar{A}^1$ = 3
$\bar{A}$	$\bar{B}$	C	$\bar{D}$	$\bar{A}^1$ = 4
A	$\bar{B}$	C	$\bar{D}$	$\bar{A}^1$ = 5
$\bar{A}$	B	C	$\bar{D}$	$\bar{A}^1$ = 6
A	B	C	$\bar{D}$	$\bar{A}^1$ = 7
$\bar{A}$	$\bar{B}$	$\bar{C}$	D	$\bar{A}^1$ = 8
A	$\bar{B}$	$\bar{C}$	D	$\bar{A}^1$ = 9

BINARY STATES REQUIRED TO LIGHT FIRST DIGIT NUMERAL

(1) BINARY A	(2) BINARY B	(4) BINARY C	(8) BINARY D	DISPLAY
A	$\bar{B}$	$\bar{C}$	$\bar{D}$	$\bar{A}^1$ = −
$\bar{A}$	B	$\bar{C}$	$\bar{D}$	$\bar{A}^1$ = 1
		OR		
A	B	$\bar{C}$	$\bar{D}$	$\bar{A}^1$ = 1
A	B	C	$\bar{D}$	$\bar{A}^1$ = OVLD

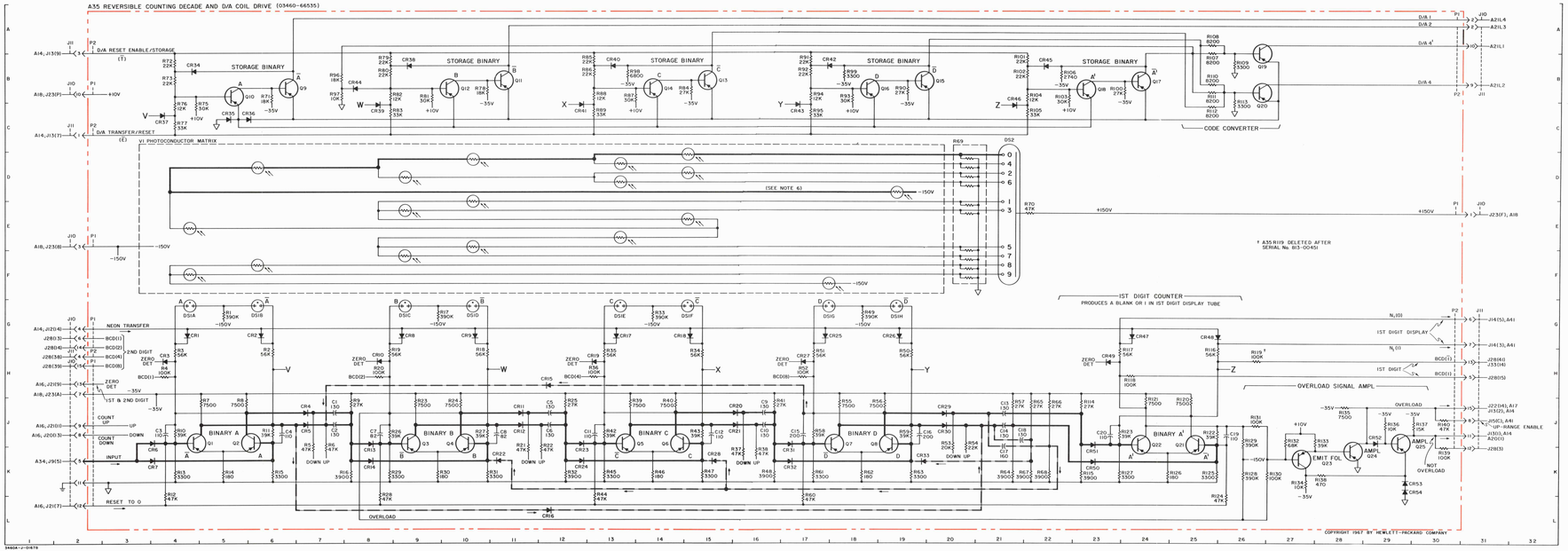


Figure 7-23. N_2 and N_1 RCD/D-to-A Coil Drive; Assembly A35 (1-2-4-8)

A39 ASSEMBLY
COMPONENT LOCATIONS

	C	CR	Q	R		CR	R		R
1	G4	J2	C5	C6	40	M3	K5	79	C3
2	F2	J3	M5	D6	41	M3	L3	80	G3
3	D2	J4	D5	D5	42	F5	K2	81	F3
4	C2	M2	L5	C6	43	G5	G6	82	G2
5	A2	M2	E5	M6	44	H6	G5	83	G2
6	D2	K4	K5	K2	45	N4	G5	84	E2
7		M4	F5	K2	46	H4	G6	85	C2
8		M4	F5	L2	47	M3	J6	86	B4
9		M4	K5	M6	48	J4	J6	87	F4
10		H2	G5	L2	49	K4	J5	88	G4
11		J3	J5	L2	50	H3	L3	89	G3
12		J4	D3	D6	51	M4	K3	90	C4
13		M2	H5	D6	52	K4	L3	91	C3
14		L2	H5	D5	53	H2	D4	92	E4
15		L2	M5	D6	54	L3	D4	93	E4
16		D5	A3	L6	55	F3	D3	94	E3
17		K5	C3	L5	56	F2	J6	95	D4
18		N4	C3	L3	57	F4	J6	96	D3
19		M3	B3	M6	58	G3	J5	97	C4
20		K4	C3	M5	59	G2	H6	98	C4
21		M3	B5	E6	60	K2	H6	99	D4
22		E5	B3	E6	61	D2	H6	100	B5
23		L4	C5	E5	62	A4	H5	101	B5
24		L3		E6	63	F3	H3	102	A5
25		F4		K6	64	F3	M4	103	B3
26		M6		K6	65	F3	N5	104	B6
27		L4		K5	66	E3	N5	105	B6
28		L4		L6	67	E4	K2	106	B6
29		K4		L5	68	G4	K3	107	C6
30		L4		F6	69	H5	K2	108	C5
31		L4		F6	70	H3	K3	109	B4
32		C5		F5	71	H4	K2	110	B4
33		J2		E6	72	A6	K3	111	M5
34		N2		F6	73	C6	K2	112	
35		K4		G6	74	H2	G4	113	
36		J3		G5	75		F2	114	
37		E4		F6	76		G4	115	
38		J3		K6	77		G2	116	
39		M2		K6	78		E2	117	

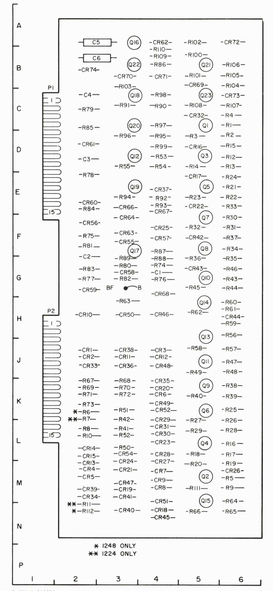


Figure 7-24. Component Location Diagram; Assembly A39 (Options 002, 003, 006, 007)

A39

NOTES

1. VALUES IN OHMS AND MICROFARADS UNLESS OTHERWISE NOTED.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED ON A39; PREFIX WITH A39.
3. ⏚ POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).
   ▽ GROUND ON ETCHED CIRCUIT BOARD.
4. ——— — — ——— DENOTES ETCHED CIRCUIT BOARD.
5. FACTORY SELECTED VALUE.

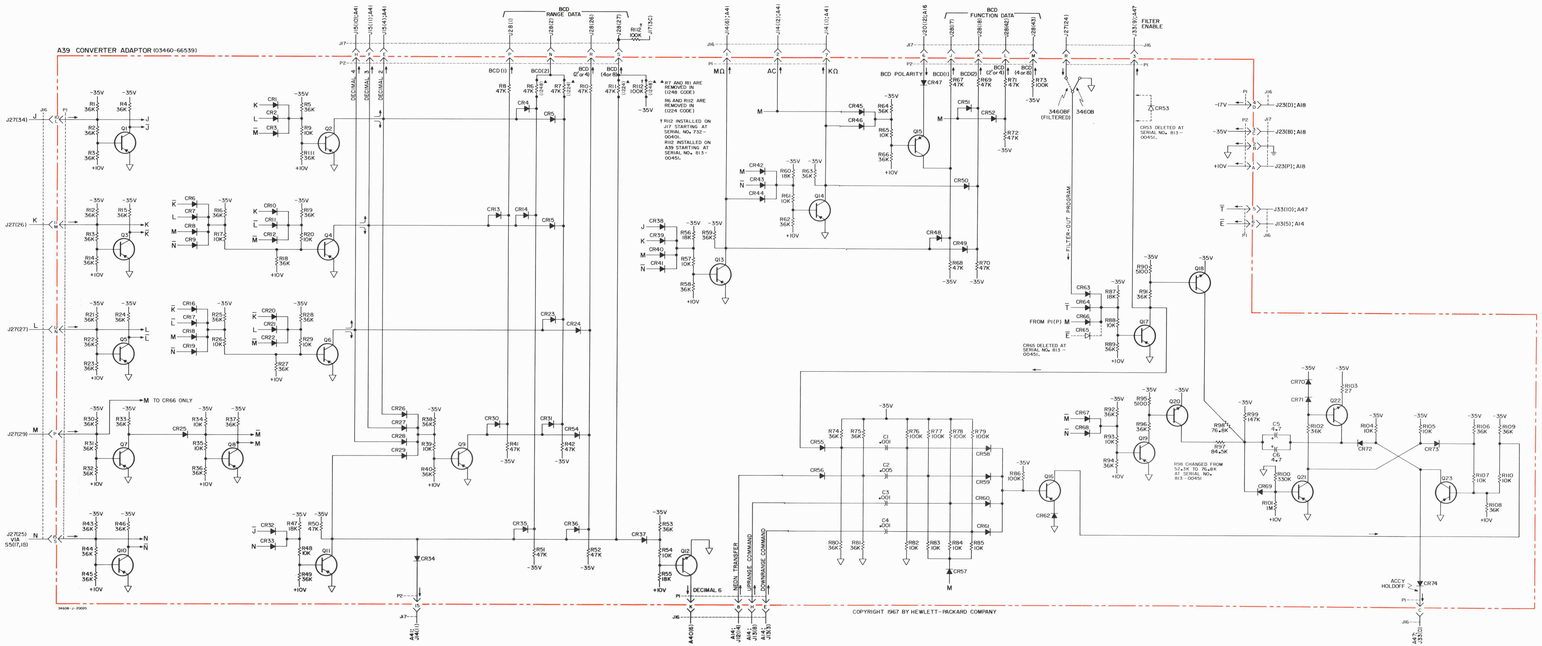
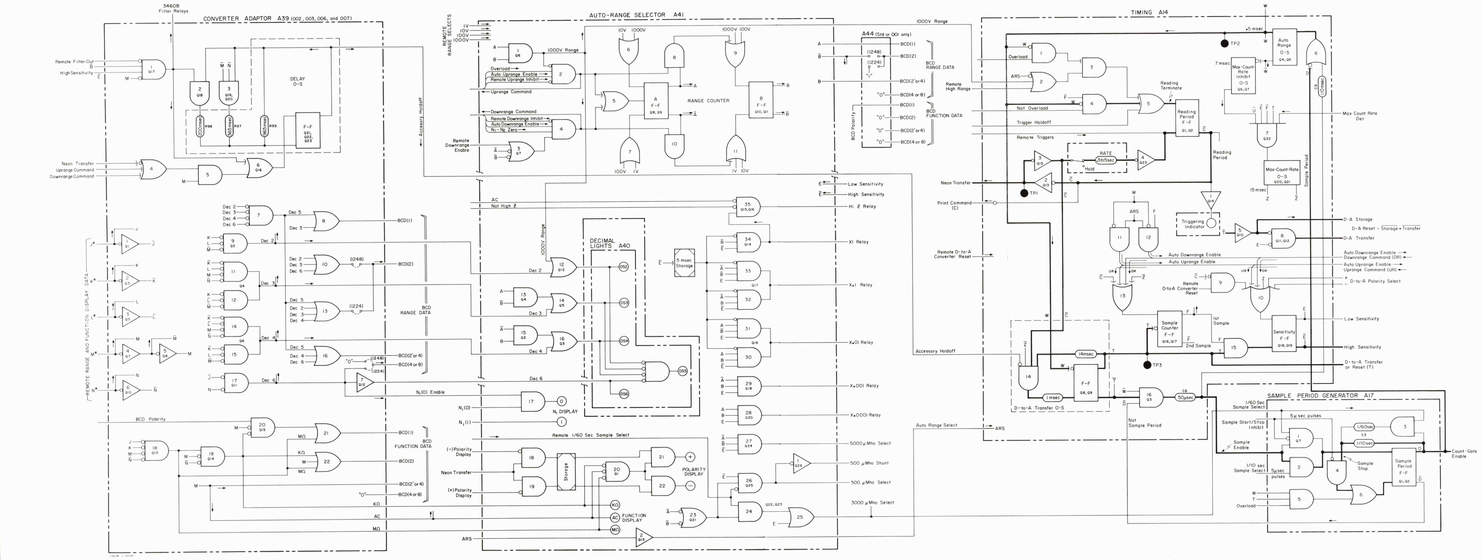
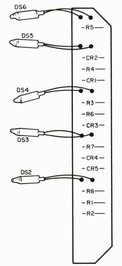
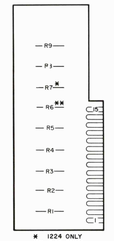


Figure 7-25. Converter Adaptor; A39







A41 ASSEMBLY COMPONENT LOCATIONS

	C	CR	Q	R		CR	R		CR	R
1	D2	B4	B3	C4	40	M5	E8	79	M2	L3
2	D2	B4	F5	B3	41	K4	D4	80		M3
3	D3	B4	B5	B6	42	J2	D6	81		K3
4	D2	C2	F4	B5	43	J2	D6	82		K3
5	L4	C2	H4	C3	44	M4	E4	83		L6
6		C2	F3	C5	45	M4	E5	84		L6
7		F6	F2	C4	46	M3	D4	85		L6
8		F6	E5	B4	47	N4	D5	86		K2
9		F6	E4	B4	48	N6	D6	87		K2
10		F6	C5	B4	49	N5	E8	88		L2
11		F4	C4	B5	50	M4	C6	89		M2
12		F4	H3	A5	51	M6	E5	90		M2
13		F4	H2	B6	52	M3	C6	91		J2
14		F4	K4	C3	53	N2	D4	92		J2
15		F4	J4	B2	54	N4	D5	93		J2
16		C5	J2	B2	55	N3	D6	94		J5
17		E4	K3	B2	56	M3	C5	95		J5
18		E4	M6	G4	57	M6	C4	96		J5
19		D4	K2	G5	58	M3	D4	97		J6
20		D4	J3	G6	59	N2	D5	98		J6
21		E4	J5	G4	60	N6	D6	99		J6
22		E4	J6	G5	61	N3	F3	100		L5
23		C5	K5	G6	62	M4	C3	101		L5
24		C3	K6	G4	63	M4	G2	102		L5
25		C2	J4	G5	64	K5	G4	103		L6
26		D3	K4	G6	65	N4	G3	104		K6
27		D3	M3	G4	66	N4	G2	105		K6
28		C3		G5	67	N5	G4	106		J4
29		D3		G6	68	J4	L4	107		K4
30		C4		G4	69	J3	K4	108		K4
31		C4		G2	70	M5	L4	109		L4
32		D4		G1	71	L4	K4	110		L4
33		D4		G3	72	E3	J4	111		L4
34		C4		G3	73	E3	J4	112		L5
35		C4		G2	74	L4	J4	113		
36		C3		F5	75	L4	J3	114		
37		D2		E6	76	L2	L3	115		
38		E2		C6	77	L2	L3	116		
39		M4		C6	78	L2	L3	117		

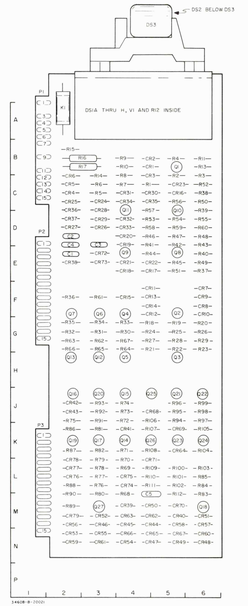


Figure 7-26. Component Location Diagrams; Assemblies A40, A41 and A44

NOTES

1. VALUES IN OHMS AND MICROFARADS UNLESS OTHERWISE NOTED.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED ON A40, A41, A44; PREFIX WITH A40, A41, A44 AS APPLICABLE.
3. ⏚ POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).
   ▽ GROUND ON ETCHED CIRCUIT BOARD.
4. ——— DENOTES ETCHED CIRCUIT BOARD.
   ▭ DENOTES FRONT PANEL MARKING.
   ⌐ ⌐ DENOTES REAR PANEL MARKING.
5. (R8, BRN) DENOTES WIRE COLOR USING STANDARD COLOR CODE. (e.g. 918 =WHITE, BROWN, GRAY)
6. VERTICALLY ALIGNED PHOTOCELLS ARE EXCITED BY THE LAMP DIRECTLY BELOW.
7. DECIMAL LIGHTS DS1, DS3, DS4, DS5, AND DS6 CORRESPOND TO FRONT PANEL DECIMAL DISPLAY FROM RIGHT TO LEFT RESPECTIVELY.
8. DS2 WITH K, M, Ω, A, AND C FUNCTIONS ON OPTION 002, 003, 006 and 007 INSTRUMENT ONLY.
9. OUTPUTS OF RANGE COUNTER ON A41 ARE APPLIED TO VARIOUS POINTS THROUGHOUT THE ASSEMBLY.
10. A44R6 IS NOT USED IN THE 1-2-4 INSTRUMENT, AND A44R7 IS NOT USED IN THE 1-2-4-8 INSTRUMENT.
11. THREE SIGNALS ENTER A41 AT J15(D): LOW RANGE, DOWNRANGE ENABLE, AND DOWNRANGE COMMAND; AND TWO SIGNALS ENTER AT J15(C): UPRANGE ENABLE AND UPRANGE COMMAND.

RANGE AND AMPLIFIER SENSITIVITY LOGIC

RANGE SELECTION A41	SENSITIVITY							
	FIRST SAMPLE PERIOD Selected by low sensitivity (E)			SECOND SAMPLE PERIOD Selected by high sensitivity ($\overline{E}$)				
			TRANSCONDUCTANCE				TRANSCONDUCTANCE	
			1/60 sec SAMPLE	1/10 sec SAMPLE				
RANGE	A41 RELAYS SELECTED BY RANGE SWITCH	INPUT ATTENUATOR SETTING	INPUT ATTENUATOR SETTING (SELECTED BY A41 RELAYS)	TRANSCONDUCTANCE (333 Ω)	INPUT ATTENUATOR SETTING	INPUT ATTENUATOR SETTING (SELECTED BY A41 RELAYS)	TRANSCONDUCTANCE (333 Ω)	
1	AB	0.1	EAB	3000 μmho	1	ĒB	Prohibited	5000 μmho (200 Ω)
10	AB	0.01	EAB	3000 μmho	1	ĒB	3000 μmho (333 Ω)	500 μmho (2000 Ω)
100	AB	0.001	EAB	3000 μmho	0.1	ĒAB	3000 μmho (333 Ω)	500 μmho (2000 Ω)
1000	AB	0.0001	EAB	3000 μmho	0.01	ĒAB	3000 μmho (333 Ω)	500 μmho (2000 Ω)

E and $\overline{E}$ originate at Sensitivity Flip-Flop on A14 Assembly.
E (low sensitivity) true when collector of A14Q18 is ≥ -25 v.
$\overline{E}$ (high sensitivity) true when collector of A14Q19 is ≥ -25 v.

Front-Panel Display

N1	N2	N3	N4	N5	N6
DS6	DS5	DS4	DS3	DS2	

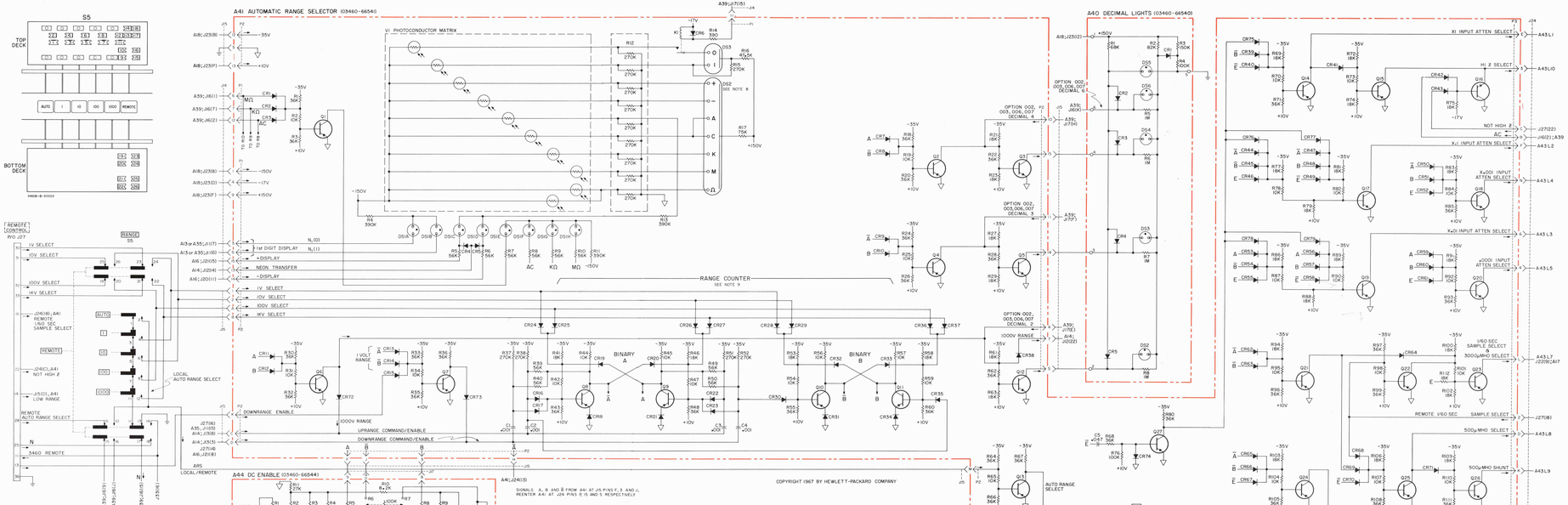
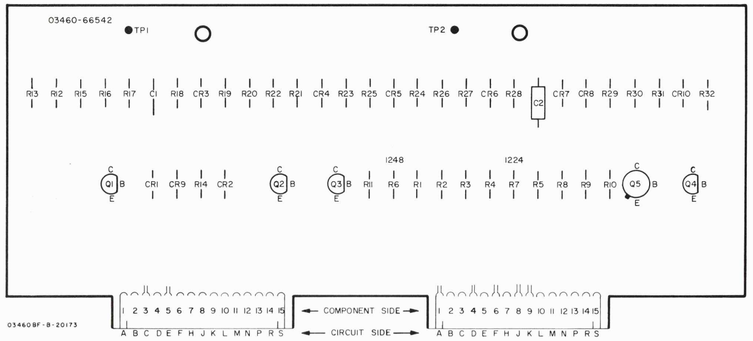


Figure 7-27. Ranging; Assemblies A40, A41 and A44

NOTES

1. VALUES IN OHMS AND PICOFARADS UNLESS OTHERWISE NOTED.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED ON A42; PREFIX WITH A42.
3. ⏚ POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).

   ▽ GROUND ON ETCHED CIRCUIT BOARD.
4. ——— — — ——— DENOTES ETCHED CIRCUIT BOARD.



A42

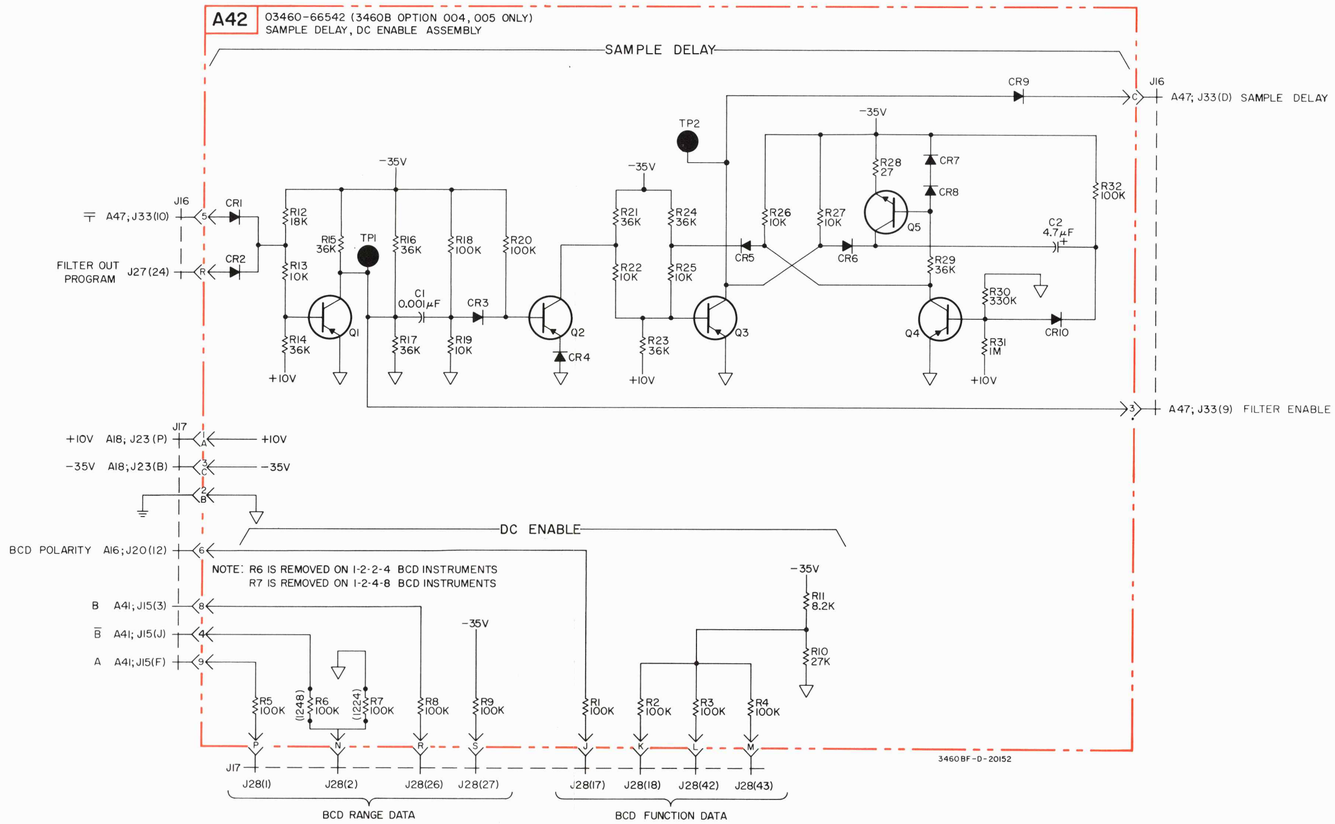
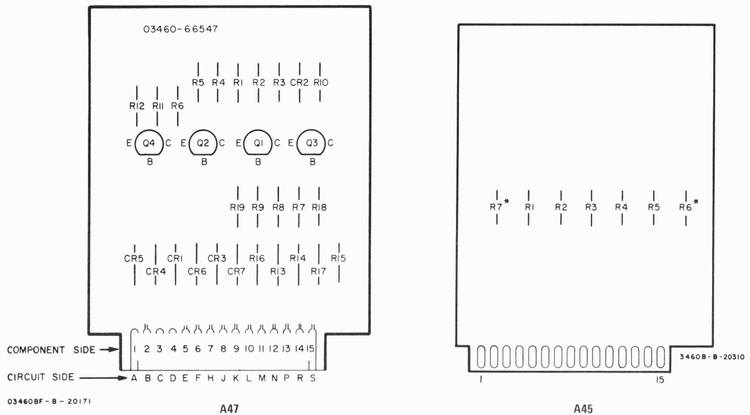


Figure 7-28. Sample Delay, DC Enable; Assembly A42

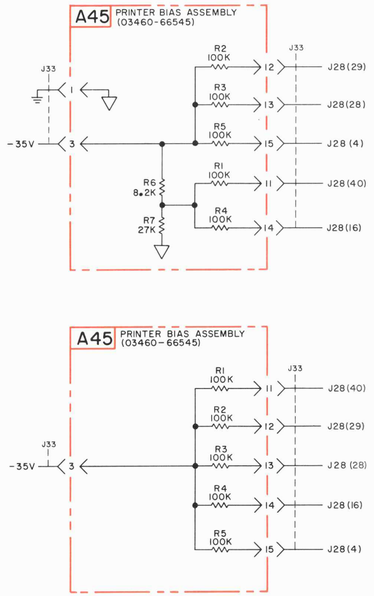
NOTES

1. VALUES IN OHMS UNLESS OTHERWISE NOTED.
2. REFERENCE DESIGNATIONS ARE ABBREVIATED ON A45 AND A47; PREFIX WITH A45 OR A47 AS APPLICABLE.
3. ⏚ POWER LINE GROUND; VOLTMETER CHASSIS (NOT GUARD OR GUARDED DECKS).

   ▽ GROUND ON ETCHED CIRCUIT BOARD.
4. ——— DENOTES ETCHED CIRCUIT BOARD.



NOTE: * INCLUDED ABOVE SERIAL NO. 813-00601



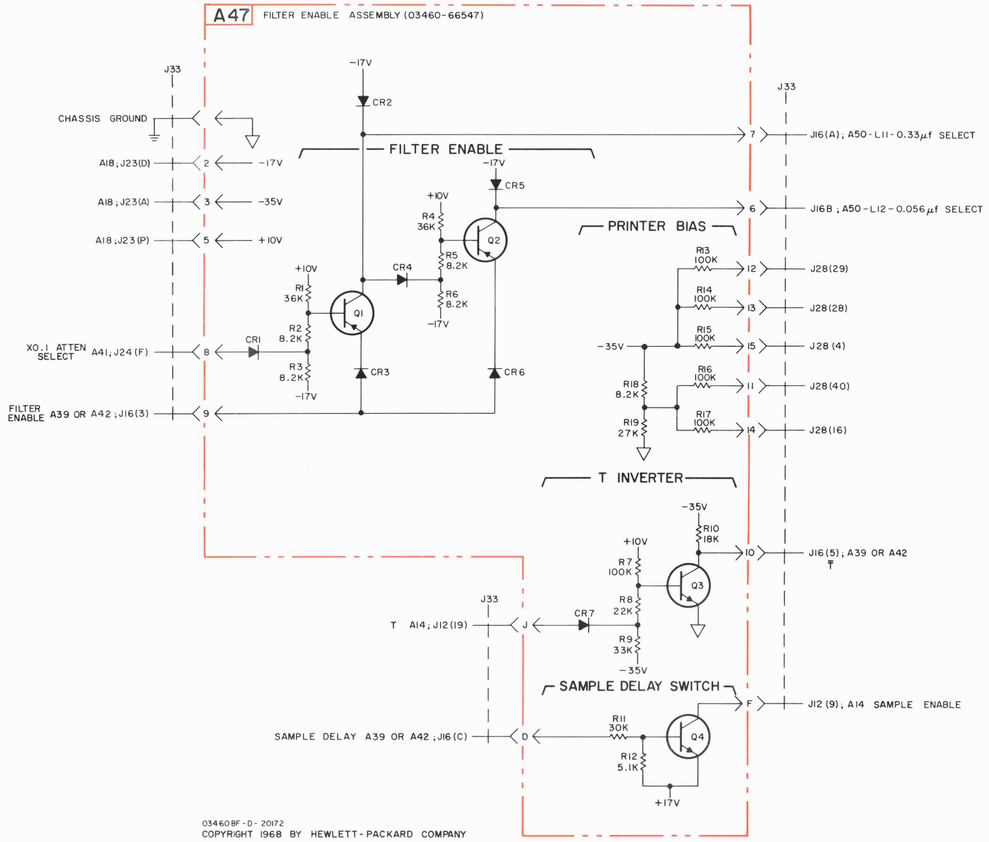
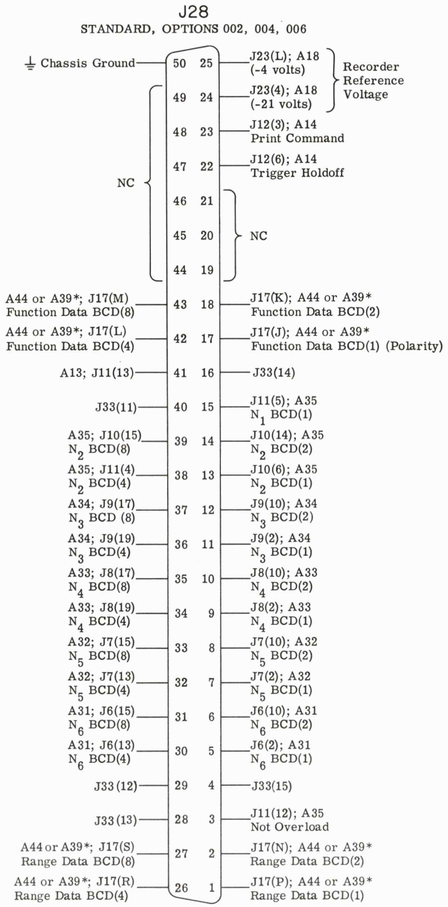


Figure 7-29. Filter Enable and Printer Bias; Assemblies A45 and A47



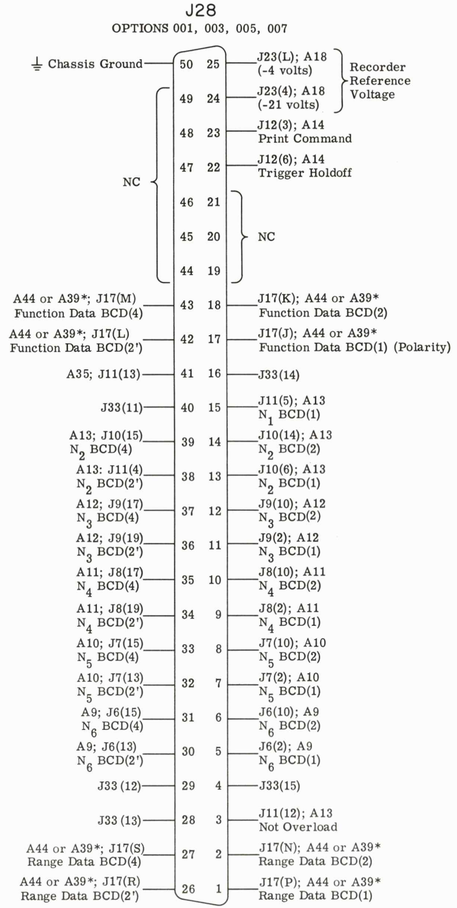
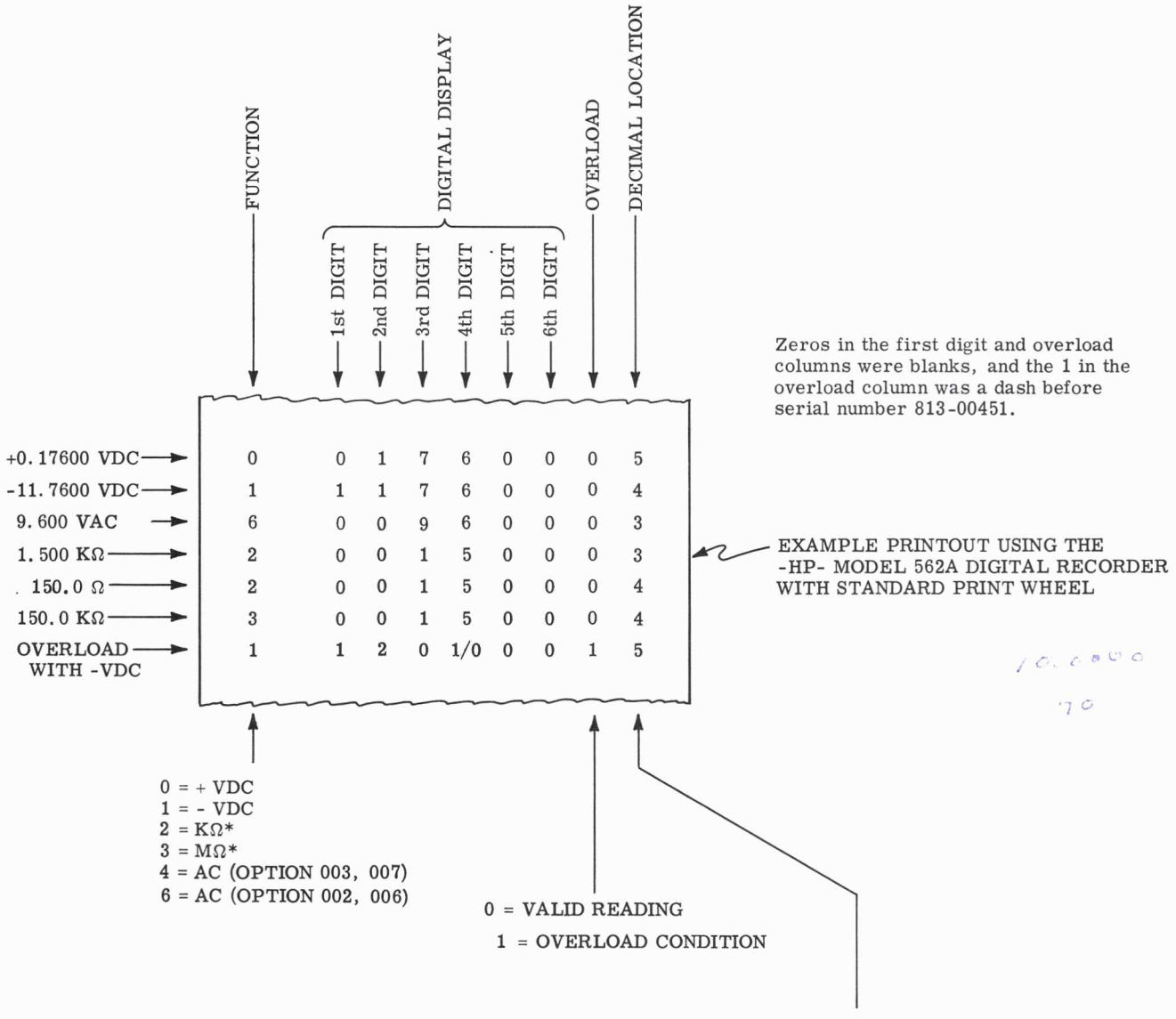


Figure 7-30. Recorder Connections



NOTES

1. ALL RECORDER CONNECTIONS ARE REFERRED TO VOLTMETER CHASSIS GROUND AND DO NOT INTERFERE WITH GUARD.
2. * DENOTES OPTION 002, 003, 006 OR 007.
3. N_1, N_2, N_3 ... DENOTES 1st, 2nd, 3rd ... DIGITS RESPECTIVELY.

DC RANGE	AC RANGE*	OHM RANGE*
*6 = ±.100000	5 = 1.00000	KΩ { 5 = 1.00000
5 = ±1.00000	4 = 10.0000	KΩ { 4 = 10.0000
4 = ±10.0000	3 = 100.000	KΩ { 3 = 100.000
3 = ±100.000	2 = 1000.00	MΩ { 5 = 1.00000
2 = ±1000.00		MΩ { 4 = 10.0000

3460B-RO

Figure 7-31. Printer Readout

CODE LIST OF MANUFACTURERS

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 Handbooks.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N.Y.
00287	Cemco Inc.	Danielson, Conn.
00334	Humidial	Colton, Calif.
00348	Microtron Co., Inc.	Valley Stream, N.Y.
00373	Garlock Inc.	Cherry Hill, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp. Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Co., Pickens Div.	Pickens, S.C.
00866	Goe Engineering Co.	City of Industry, Cal.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
00929	Microlab Inc.	Livingston, N.J.
01002	General Electric Co., Capacitor Dept.	Hudson Falls, N.Y.
01009	Alden Products Co.	Brockton, Mass.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc., Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01670	Gudebrod Bros. Silk Co.	New York, N.Y.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02116	Wheelock Signals, Inc.	Long Branch, N.J.
02286	Cole Rubber and Plastics Inc.	Sunnyvale, Calif.
02660	Amphenol-Borg Electronics Corp.	Broadview, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
02875	Hudson Tool & Die Co.	Newark, N.J.
03508	G.E. Semiconductor Prod. Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	Compton, Calif.
03818	Parker Seal Co.	Los Angeles, Calif.
03877	Transitron Electric Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N.J.
03954	Singer Co., Diehl Div. Finderne Plant	Sumerville, N.J.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N.J.
04062	Arco Electronic Inc.	Great Neck, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04354	Precision Paper Tube Co.	Wheeling, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Products, Microwave Device Div.	Mountain View, Calif.
04673	Dakota Engr. Inc.	Culver City, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P.M. Motor Company	Westchester, Ill.
04919	Component Mfg. Service Co.	W. Bridgewater, Mass.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05245	Components Corp.	Chicago, Ill.
05277	Westinghouse Electric Corp. Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05397	Union Carbide Corp., Elect. Div.	New York, N.Y.
05574	Viking Ind. Inc.	Canoga Park, Calif.
05593	Icore Electro-Plastics Inc.	Sunnyvale, Calif.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metro-Tel Corp.	Westbury, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	Bassick Co., Div. of Stewart Warner Corp.	Bridgeport, Conn.
06090	Raychem Corp.	Redwood City, Calif.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06540	Amatom Electronic Hardware Co., Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06666	General Devices Co., Inc.	Indianapolis, Ind.
06751	Components Inc., Ariz. Div.	Phoenix, Ariz.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
06980	Varian Assoc. Eimac Div.	San Carlos, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N.Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07256	Silicon Transistor Corp.	Carle Place, N.Y.
07261	Avnet Corp.	Culver City, Calif.
07263	Fairchild Camera & Inst. Corp. Semiconductor Div.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	Birtcher Corp., The	Monterey Park, Calif.
07397	Sylvania Elect. Prod. Inc., Mt. View Operations	Mountain View, Calif.
07700	Technical Wire Products Inc.	Cranford, N.J.
07829	Bodine Elect. Co.	Chicago, Ill.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, Calif.
07980	Hewlett-Packard Co., Boonton Radio Div.	Rockaway, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08524	Deutsch Fastener Corp.	Los Angeles, Calif.
08664	Bristol Co., The	Waterbury, Conn.
08717	Sloan Company	Sun Valley, Calif.
08718	ITT Cannon Electric Inc., Phoenix Div.	Phoenix, Arizona
08727	National Radio Lab. Inc.	Paramus, N.J.
08792	CBS Electronics Semiconductor Operations, Div of C.B.S. Inc.	Lowell, Mass.
08806	General Electric Co. Miniat. Lamp Dept.	Cleveland, Ohio
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays Div.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Tech. Ind. Inc. Atohm Elect.	Burbank, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09353	C & K Components Inc.	Newton, Mass.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
09922	Burndy Corp.	Norwalk, Conn.
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11242	Bay State Electronics Corp.	Waltham, Mass.
11312	Teledyne Inc., Microwave Div.	Palo Alto, Calif.
11314	National Seal	Downey, Calif.
11453	Precision Connector Corp.	Jamaica, N.Y.
11534	Duncan Electronics Inc.	Costa Mesa, Calif.
11711	General Instrument Corp., Semiconductor Div., Products Group	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12040	National Semiconductor	Danbury, Conn.
12136	Philadelphia Handle Co.	Camden, N.J.
12361	Grove Mfg. Co., Inc.	Shady Grove, Pa.
12574	Gulton Ind. Inc. Data System Div.	Albuquerque, N.M.
12697	Clarostat Mfg. Co.	Dover, N.H.
12728	Elmar Filter Corp.	W. Haven, Conn.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12881	Metex Electronics Corp.	Clark, N.J.
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
12954	Dickson Electronics Corp.	Scottsdale, Arizona
13103	Thermolloy	Dallas, Texas
13396	Telefunken (GmbH)	Hanover, Germany
13835	Midland-Wright Div. of Pacific Industries, Inc.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14433	ITT Semiconductor, A Div. of Int. Telephone & Telegraph Corp.	West Palm Beach, Fla.
14493	Hewlett-Packard Company	Loveland, Colo.
14655	Cornell Dublier Electric Corp.	Newark, N.J.
14674	Corning Glass Works	Corning, N.Y.
14752	Electro Cube Inc.	San Gabriel, Calif.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co.	New York, N.Y.
15287	Scionics Corp.	Northridge, Calif.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15558	Micron Electronics	Garden City, Long Island, N.Y.
15566	Amprobe Inst. Corp.	Lynbrook, N.Y.
15631	Cabletronics	Costa Mesa, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15801	Fenwal Elect. Inc.	Framingham, Mass.
15818	Amelco Inc.	Mt. View, Calif.
16037	Spruce Pine Mica Co.	Spruce Pine, N.C.
16179	Omni-Spectra Inc.	Farmington, Mich.
16352	Computer Diode Corp.	Lodi, N.J.
16585	Boots Aircraft Nut Corp.	Pasadena, Calif.
16688	Ideal Prec. Meter Co., Inc. De Jur Meter Div.	Brooklyn, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokoma, Ind.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
17554	Components Inc.	Biddeford, Ma.
17675	Hamlin Metal Products Corp.	Akron, Ohio
17745	Angstrohm Prec. Inc.	No. Hollywood, Calif.

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
17870	McGraw-Edison Co.	Manchester, N.H.
18042	Power Design Pacific Inc.	Palo Alto, Calif.
18083	Clevite Corp., Semiconductor Div.	Palo Alto, Calif.
18324	Signetics Corp.	Sunnyvale, Calif.
18476	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
18486	TRW Elect. Comp. Div.	Des Plaines, Ill.
18583	Curtis Instrument, Inc.	Mt. Kisco, N.Y.
18612	Vishay Instruments Inc.	Malvern, Pa.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
18911	Durant Mfg. Co.	Milwaukee, Wis.
19315	The Bendix Corp., Navigation & Control Div.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19589	Concoa	Baldwin Park, Calif.
19644	LRC Electronics	Horseheads, N.Y.
19701	Electra Mfg. Co.	Independence, Kansas
20183	General Atronics Corp.	Philadelphia, Pa.
21226	Executone, Inc.	Long Island City, N.Y.
21335	Fafnir Bearing Co., The	New Britain, Conn.
21520	Fansteel Metallurgical Corp.	N. Chicago, Ill.
23042	Texscan Corp.	Indianapolis, Ind.
23783	British Radio Electronics Ltd.	Washington, D.C.
24455	G.E. Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
24681	Memcor Inc., Comp. Div.	Huntington, Ind.
24796	Parelco Inc.	San Juan Capistrano, Calif.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26851	Compac/Hollister Co.	Hollister, Calif.
26992	Hamilton Watch Co.	Lancaster, Pa.
27251	Specialities Mfg. Co., Inc.	Stratford, Conn.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
30817	Instrument Specialties Co., Inc.	Little Falls, N.J.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Coil Products Ltd.	Hawkesbury, Ontario, Canada
36287	Cunningham, W.H. & Hill, Ltd.	Toronto Ontario, Canada
37942	P.R. Mallory & Co. Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
46384	Penn Eng. & Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer & Inst. Co.	Southampton, Pa.
49956	Microwave & Power Tube Div.	Waltham, Mass.
52090	Rowan Controller Co.	Westminster, Md.
52983	Sanborn Company	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Raytheon Co. Commercial Apparatus & Systems Div.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex Corp.	Tulsa, Okla.
59730	Thomas & Betts Co.	Elizabeth, N.J.
60741	Triplett Electrical Inst. Co.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Inc. Weston-Newark	Newark, N.J.
66295	Wittek Mfg. Co.	Chicago, Ill.
66346	Minnesota Mining & Mfg. Co. Revere Mincom Div.	St. Paul, Minn.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control	New York, N.Y.
70318	Allmetal Screw Product Co., Inc.	Garden City, N.Y.
70417	Amplex, Div. of Chrysler Corp.	Detroit, Mich.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	Union City, N.J.
70674	ADC Products Inc.	Minneapolis, Minn.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71034	Bliley Electric Co., Inc.	Erie, Pa.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionics Corp.	Cambridge, Mass.
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Cardwell Condenser Corp.	Lindenhurst L.I., N.Y.
71400	Bussmann Mfg. Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71447	Calif. Spring Co., Inc.	Pico-Rivera, Calif.
71450	CTS Corp.	Elkhart, Ind.
71468	ITT Cannon Electric Inc.	Los Angeles, Calif.
71471	Cinema, Div. Aerovox Corp.	Burbank, Calif.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	Cornish Wire Co., The	New York, N.Y.
71707	Coto Coil Co., Inc.	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co., Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	Indiana General Corp., Electronics Div.	Keasby, N.J.
72699	General Instrument Corp., Cap. Div.	Newark, N.J.
72765	Drake Mfg. Co.	Harwood Heights, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72962	Elastic Stop Nut Corp.	Union, N.J.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Technological Products, Inc.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Inst., Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Elect Co.	Hicksville, L.I., N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73586	Circle F Mfg. Co.	Trenton, N.J.
73682	George K. Garrett Co., Div. MSL Industries Inc.	Philadelphia, Pa.
73734	Federal Screw Products Inc.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	General Industries Co., The	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Corp.	San Jose, Calif.
73957	Groov-Pin Corp.	Ridgefield, N.J.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75263	Keystone Carbon Co., Inc.	St. Marys, Pa.
75378	CTS Knights Inc.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	General Instrument Corp., Micamold Division	Newark, N.J.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Cinch-Monadnock, Div. of United Carr Fastener Corp.	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76703	National Union	Newark, N.J.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	The Bendix Corp., Electrodynamics Div.	N. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phanostran Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine & Foundry Co. Potter & Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77638	General Instrument Corp., Rectifier Div.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78277	Sigma	So. Braintree, Mass.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78424	Speciality Leather Prod. Co.	Newark, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	San Gabriel, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79136	Waldes Kohinoor Inc.	Long Island City, N.Y.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products Co.	Elizabeth, N.J.
80131	Electronic Industries Association. Any brand Tube meeting EIA Standards-Washington, DC.	
80207	Unimax Switch, Div. Maxon Electronics Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Controls Co.	Columbus, Ohio

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Label Co.	Monrovia, Calif.
80583	Hammarlund Co., Inc.	Mars Hill, N.C.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
80813	Dimco Gray Co.	Dayton, Ohio
81030	International Instruments Inc.	Orange, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Elec. Div. Litton Ind., Inc.	Oakville, Conn.
81349	Military Specification	. . . . .
81483	International Rectifier Corp.	El Segundo, Calif.
81541	Airpax Electronics, Inc.	Cambridge, Maryland
81860	Barry Controls, Div. Barry Wright Corp.	Watertown, Mass.
82042	Carter Precision Electric Co.	Skokie, Ill.
82047	Sperti Faraday Inc., Copper Hewitt Electric Div.	Hoboken, N.J.
82116	Electric Regulator Corp.	Norwalk, Conn.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Fairchild Camera & Inst. Corp. Space & Defense System Div.	Paramus, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Division	Emporium, Pa.
82376	Astron Corp.	East Newark, Harrison, N,J,
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals & Controls Inc. Spencer Products	Attleboro, Mass.
82768	Phillips-Advance Control Co.	Joliet, Ill.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83014	Hartwell Corp.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	General Instrument Corp., Capacitor Div.	Darlington, S.C.
83148	ITT Wire and Cable Div.	Los Angeles, Calif.
83186	Victory Eng. Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
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91886	Malco Mfg. Co., inc.	Chicago, Ill.
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000MM	Rubber Eng. & Development	Hayward, Calif.
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